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THESIS

REQUIREMENTS ANALYSIS FOR EFFECTIVE
MANAGEMENT INFORMATION SYSTEMS DESIGN:
A FRAMEWORK AND CASE STUDY

by

John Charles Gerhard, III

December 1981

Co-Advisors: D. C. Boger
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Many firms employ automated information processing systems as an aid to managerial decision making. Few information systems, however, fully achieve their intended goal. To improve the probability of creating an effective management information system, designers must first identify the relevant processes that require information support. To meet this need a decision-oriented approach to information requirements analysis is presented. Then

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Requirements Analysis for Effective Management Information Systems Design: A Framework and Case Study

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ABSTRACT

Many firms employ automated information processing systems as an aid to managerial decision making. Few information systems, however, fully achieve their intended goal. To improve the probability of creating an effective management information system, designers must first identify the relevant processes that require information support. To meet this need a decision-oriented approach to information requirements analysis is presented. Then the analytic framework is illustrated through a case study of an information system that is being developed within the Department of Defense.

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I. INTRODUCTION

Organizations have long required systems for collecting, processing, storing, retrieving, and distributing information. The introduction of commercial computers in the mid-1950's has had an unparalleled effect on the ability of firms to accomplish these information processing tasks. Most early applications of computer technology focused on improving the efficiency of routine clerical jobs. As the cost of hardware declined, and high level software languages became available, the use of computers was extended beyond the realm of transaction processing into the area of management decision making. This new dimension has become known as management information systems (MIS).

A MIS is generally understood to be an integrated, man/machine system designed to provide information support for operational control and managerial decision making. Such a system employs computer hardware and software, decision models, and a database. To be effective a MIS must be designed to support all levels of management decision activity--from the well-defined requirements of first line supervision to the ill-structured problems of top management.

Although the goals of a MIS are clear, these goals have rarely been achieved. The main impact of most MIS's has been on structured tasks where standard operating procedures,

decision rules, and information flows can readily be defined. As a result of this emphasis managers have frequently been overwhelmed by a morass of structured information that does not serve their decision making needs. This lack of support occurs because managers most often deal with unstructured, nonroutine problems. Consequently, for MIS's to become useful a new approach to their design is required. To meet this need a top-down approach to management information requirements analysis shall be presented, and its application will be illustrated through a case study.

The case study will examine an actual MIS that is being planned within the Department of Defense. The three Military Medical Departments are now developing a comprehensive MIS that is intended to both improve and integrate the processing of medical management information. The name of this project is the Tri-Service Medical Information System (TRIMIS). This thesis will examine one functional element of the TRIMIS effort--food service--and illustrate a decision-oriented approach to information requirements analysis that may serve as a framework for designing effective systems of decision support.

A. OVERVIEW OF TRI-SERVICE MEDICAL INFORMATION SYSTEM

1. Purpose of TRIMIS

The United States Army, Navy, and Air Force have each developed comprehensive health care systems for service

personnel and their dependents. In most cases these efforts have been independently undertaken. As a result, a substantial amount of time and money has been spent in developing duplicate medical information systems. Also, computer-based medical information systems developed by one Department usually have not been compatible with those of other Departments. This incompatibility has limited the sharing of resources.

In addition to these problems, the Military Departments are facing a significant decrease in the retention of physicians and other members of the health care team. This decrease is occuring at a time when the complexity of medical care is increasing and the population to be supported is growing. Thus, relief from the operational workload in health care is urgently needed.

To address these and many other military health care concerns, the TRIMIS Program was initiated in 1975. The purposes of the TRIMIS automation effort are to:

a) Reduce administrative and management costs in military health care facilities, freeing funds for essential health care services;

b) Decrease the administrative workload for medical personnel so that they may devote their efforts to direct health care; and

c) Promote greater administrative and management efficiency in medical facilities.

Overall guidance for the TRIMIS Program is provided by the Office of the Secretary of Defense. The Assistant

Secretary of Defense (Health Affairs) oversees all aspects of the TRIMIS Program, receiving guidance in systems acquisition and fiscal matters from the Assistant Secretary of Defense (Controller). The TRIMIS Steering Group, which includes the Surgeons General of the Military Departments, regularly reviews the TRIMIS Program and offers recommendations.

2. Scope of TRIMIS Effort

The TRIMIS Program is a broad-based approach to the information processing needs of military medical facilities. The scope of effort includes the following administrative and clinical areas:

a) Medical Management Information,

b) Patient Appointments and Scheduling,

c) Patient Administration,

d) Wards and Clinics,

e) Pharmacy,

f) Dental,

g) Radiology,

h) Laboratory,

i) Logistics, and

j) Food Service.

3. TRIMIS Program Goals

TRIMIS Systems will be designed to support patient care, assist health care providers, and enhance the operation and management of Medical Treatment Facilities (MTF's).

Through its data processing capabilities TRIMIS is intended to achieve the following goals:

a) Effectiveness - make medical information needed for quality health care available on a convenient and timely basis;

b) Efficiency - automate routine functions in work centers;

c) Coordination - centralize the planning, acquisition, installation, management, evaluation, and maintenance of automated systems;

d) Standardization - permit information collection and transfer among systems; effect cost reductions for training, management, procurement, operation, and maintenance;

e) Adaptability - allow systems to be used in various sizes and types of medical facilities;

f) Modernization - replace or improve existing systems and integrate them with new systems; and

g) Streamlining - ensure that information flows smoothly among medical facilities while minimizing the need for computer support personnel.

B. FOOD SERVICE AS A FUNCTIONAL ELEMENT OF TRIMIS

1. Background of TRI-Food System

At the request of the TRIMIS Project Office (TPO), nominations were submitted by each service to the TPO, and a Tri-Service Food Service Committee was established in April 1977. The committee was chaired by a TPO action officer for the TRI-Food System. The committee members were assisted by the TPO and Hospital Affiliates International, Inc. in the design and development of a summary functional requirement (SFR). The SFR defines the basic Tri-Service requirements

for automatic data processing support for food service in terms of required capabilities, operational environment, and impact of implementation. Resources for design of the TRIMIS Food Service System will be authorized based upon these requirements and the current needs of the TRI-Food Committee.

2. Scope of TRI-Food Effort

TRIMIS Food Service System capabilities and functional modules are defined to satisfy the operational food service requirements of various MTF's. These facilities vary in size and type of service provided. MTF's range from the large medical center providing a full complement of inpatient and outpatient services to the small clinic where technical personnel provide limited services.

Food service requirements are defined in discrete groups of functional processes. This organization of processes permits each MTF to implement only those modules required to support current food services with enhancement capability as requirements change.

3. TRI-Food SFR Modules

The TRI-Food SFR defines functional requirements for data processing capability through a modular approach. Each module is divided into applications. Applications are further subdivided into activities. Activity requirements provide a description of specific tasks within each module at the logical, rather than physical, level.

The TRI-Food SFR [Ref. 1] describes the following modules:

a) Inpatient Module,

b) Outpatient Module,

c) Nutritional Analysis Module,

d) Planning Module,

e) Inventory Module,

f) Production Module,

g) Service Module,

h) Financial Management Module,

i) Personnel Module,

j) Training Module,

k) Quality Control Module, and

l) Research Module.

4. <u>TRI-Food Working Committee Efforts Since 1978</u>

Since 1978 the TRI-Food Working Committee has held frequent meetings to conduct an ongoing review of SFR module requirements. Refinements identified by the committee are intended to maintain the validity of the TRI-Food SFR during the current period of system development. Efforts of the committee also include interservice site visits, data definition and terminology standardization, and food service system interface requirements.

C. METHODOLOGY

A decision-oriented method of requirements analysis for information systems shall be presented in this thesis. To illustrate this approach the discussion will examine the decision processes of military medical food service managers. The intent of this treatment is not to criticize the work of the TRI-Food Committee but to identify potential weaknesses in and suggest improvements to the specifications of the current TRI-Food SFR. It is hoped that this effort will assist in developing a MIS that genuinely supports all levels of food service management.

Chapters II through IV will construct a framework for the analysis of information requirements. Chapters V through VII will illustrate the use of the framework. The following summaries are presented as a preview of the major topics that will be developed in each chapter:

Part I:
A Framework for Information Requirements Analysis

a) Chapter II - discuss the development of the classic Gorry and Scott Morton framework for MIS design; analyze the TRI-Food SFR within this framework; note significant weaknesses in the SFR;

b) Chapter III - discuss the philosophy and design of decision support systems; present models for requirements analysis and design of decision support systems;

c) Chapter IV - develop a generalized, normative model for decision analysis of strategic planning information requirements;

Part II: A Case Study Application of the Framework

d) Chapter V - perform a descriptive analysis of military medical food service within the parameters of the model developed in Chapter IV; compare the descriptive analysis with the normative model and note variances between the two models; determine which variances are due to information uncertainty; identify requirements for decision support systems that will reduce variances caused by information uncertainty;

e) Chapter VI - explore design alternatives for decision support requirements identified in Chapter V; suggest specific decision support software solutions to include in the TRI-Food MIS; and

f) Chapter VII - present conclusions from the TRI-Food System information requirements analysis; make recommendations for action by the TRIMIS Program Office and the TRI-Food Committee.

II. HYPOTHESIS

This chapter will review the foundations of a classic framework for MIS design. The model is notable because it examines managerial information processing from two points of view--the organizational level of managerial activity and the structure of the problem to be solved. The TRI-Food SFR will then be analyzed within this model to determine if it robustly satisifies these two dimensions. Then potential weaknesses of the SFR will be noted.

A. FRAMEWORK FOR A MANAGEMENT INFORMATION SYSTEM

1. Purpose of a MIS

Gorry and Scott Morton [Ref. 2: pp. 56] state that information systems should exist only to support decisions made in an organization. Their now classic MIS framework looks for a characterization of organizational activity in terms of the types of decisions required. Such an understanding of managerial activity is a prerequisite for effective MIS design and implementation.

2. Levels of Planning and Control Systems

In attempting to understand the evolution and problems of management information systems Gorry and Scott Morton have found the work of Robert Anthony and Herbert Simon to be

particularly useful. In Planning and Control Systems: A Framework for Analysis, Anthony addresses the problem of developing a classification scheme that provides management with a perspective when examining planning and control systems. Anthony's taxonomy of managerial activity includes:

a) Strategic Planning - the process of deciding on the objectives of an organization, on changes in these objectives, on the resources used to attain objectives, and on the policies that are to govern the acquisition, use, and disposition of resources;

b) Management Control - the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organizational objectives; and

c) Operational Control - the process of assuring that specific tasks are carried out effectively and efficiently.

The information requirements of each activity are quite different. Strategic planning is concerned with setting broad policies for the organization. As a result, the relationship of the organization and its environment is of primary importance. Both the scope and variety of information are quite large, but the need for accuracy is not particularly stringent. Finally, the infrequent nature of the strategic planning process means that the demands for this type of information occur in a nonregular fashion.

At the opposite end of the information spectrum is the area of operational control. The task orientation of operational control requires information of a well-defined and narrow scope. This information is quite detailed and

arises largely from sources within the organization. Very frequent use is made of this information, and it must therefore be accurate.

The information needs of management control fall between the extremes of operational control and strategic planning. In addition, it is important to recognize that much of the information relevant to management control is obtained through the process of human interaction.

Gorry and Scott Morton [Ref. 2: pp. 59] summarize these general observations concerning the catagories of management activity in Figure 1. Figure 1 underscores their contention that since the activities themselves are different, the information requirements to support them are also quite different.

3. Process of Decision Making

Gorry and Scott Morton [Ref. 2: pp. 60] discuss the applicability to MIS of Herbert Simon's work concerning the decision making process. In The New Science of Management Decision, Simon states that all problem solving can be broken down into three phases:

a) Intelligence - the process of searching the environment for conditions that call for a decision;

b) Design - the process of inventing, developing, and analyzing possible alternative courses of action; and

c) Choice - the process of selecting a course of action from the possible alternatives.

CHARACTERISTICS	OPERATIONAL CONTROL	MANAGEMENT CONTROL	STRATEGIC PLANNING
Source	Internal	<========>	External
Scope	Well-defined	<========>	Very Wide
Aggregation	Detailed	<========>	Aggregate
Time Horizon	Historical	<========>	Future
Currency	Very Current	<========>	Quite Old
Required Accuracy	High	<========>	Low
Frequency of Use	Very Frequent	<========>	Infrequent

Figure 1: Information Requirements by Decision Category

Simon is also concerned with the manner in which human beings solve problems, regardless of their position within an organization. He distinguishes between "programmed" and "nonprogrammed" decisions. Decisions are programmed to the extent that a routine procedure has been established for dealing with them so that they do not have to be treated at new each time they occur. Decisions are nonprogrammed to the extent that they are novel, unstructured, and consequential; there is no specific procedure to deal with these problems, and the decision maker must rely on whatever general capacity he or she has for intelligent, adaptive, problem-oriented action.

Gorry and Scott Morton [Ref. 2: pp. 61] substitute the terms "structured" and "unstructured" for programmed and nonprogrammed because these terms imply less dependence on the computer and more dependence on the basic character of the problem solving activity in question. A fully structured problem is one in which all three phases--intelligence, design, and choice--are structured. One may specify algorithms or decision rules that will allow him or her to find the problem, design alternative solutions, and select the best solution. An unstructured problem is one in which none of the three phases is structured.

Gorry and Scott Morton [Ref. 2: pp. 62] present a matrix (Figure 2) that combines the taxonomies of both

	OPERATIONAL CONTROL	MANAGEMENT CONTROL	STRATEGIC PLANNING
STRUCTURED TASKS	Accounts Receivable	Budget Analysis	Distribution Systems
(SDS) ==>	Inventory Control	Short Term Forecasting	Factory Location
SEMI-STRUCTURED	Production Scheduling	Variance Analysis	Acquisitions & Mergers
(DSS) ==>	Cash Management	Budget Preparation	New Product Planning
UNSTRUCTURED TASKS	PERT/COST Systems	Sales & Production	R&D Planning

Figure 2: Framework for Mangement Information Systems

Anthony and Simon. Decision modules above the semi-structured task line are largely structured. Gorry and Scott Morton identify the information systems that support these decisions as "Structured Decision Systems (SDS)". Decisions below the line are largely unstructured, and their supporting information systems are termed "Decision Support Systems (DSS)".

By developing a decision model for a given problem solving process, one may establish the character of each of Simon's decision phases. If each phase can be structured, a structured decision system might then be designed. For those processes which are unstructured, the MIS designer would have to call upon the manager to provide the necessary problem analysis. An unstructured problem might then be broken down into a set of related subproblems, some of which might be solved automatically by the system and the remainder by the user either alone or with varying degrees of computational and display support, i.e. decision support systems.

The Gorry and Scott Morton framework provides valuable insight into the design and implementation of management information systems. Todate most MIS activity has been directed at decisions in the structured half of the matrix, specifically in the "operational control" cell. Managers, however, deal primarily with unstructured decisions. This implies that computers and related systems, which have so far

been largely applied to the structured operational control area, have not yet had any real impact on management decision making. The fact that an integrated MIS should be developed to support all levels of management activity requires that a MIS effort address unstructured, as well as structured, decision making needs. Thus, the Gorry and Scott Morton framework might be used to examine the robustness of a tentative MIS design.

B. ANALYSIS OF TRI-FOOD SFR

1. Analysis of TRI-Food SFR within Gorry and Scott Morton's Framework

An analysis of the proposed TRI-Food SFR modules within the Gorry and Scott Morton framework is presented in Figure 3. The training and quality control modules were included under management control, instead of strategic planning, because neither of these modules addresses mechanisms by which to integrate their data with food service organizational objectives. Both modules serve primarily as data stores (files) for past activity in their area of interest.

2. Conclusions and Hypothesis

Conclusions that may be inferred from the analysis presented in Figure 3 are:

a) There is currently little emphasis on strategic planning; and

b) There is only minimal support for unstructured decision making, i.e. Decision Support Systems.

	OPERATIONAL CONTROL	MANAGEMENT CONTROL	STRATEGIC PLANNING
STRUCTURED TASKS (SDS) ==>	Inpatient Outpatient Inventory Service Personnel	Nutritional Analysis Financial Management Short-Term Forecasts Quality Control Training	
SEMI-STRUCTURED (DSS) ==> UNSTRUCTURED TASKS	Production Scheduling	Menu Planning	Research

Figure 3: Analysis of Tri-Food SFR Modules

Since a management information system should serve to support managers in all aspects of their information needs, it is hypothesized that the current TRI-Food SFR is an incomplete MIS. Specifically, to become a robust MIS the SFR needs to incorporate more support for strategic planning and a broader scope of decision support systems.

The following chapter shall discuss the fundamental philosophies that are inherent in effective systems of decision support. Once these concepts are presented, the discourse shall investigate models for the design of decision support systems. These models shall include a predesign cycle for decision requirements analysis and a design cycle for building systems that satisfy information requirements identified in the predesign cycle.

III. DECISION SUPPORT SYSTEM DESIGN CONCEPTS

The preceding chapter offered a framework by which to evaluate the completeness of a MIS design. The TRI-Food SFR was then analyzed within that framework. From this analysis it was observed that the SFR failed to provide adequate support for strategic planning activities and unstructured decision making.

Since the concept of decision support systems is not well understood, this chapter will discuss the important issues and strategies that should be considered in the design of such systems. This summary shall focus on methods for building implementable models that facilitate managerial decision making. It is through the construction of decision models that structure is added to problem solving. From these models software programs may then be written. Finally, methods will be illustrated that may assist designers in developing effective decision support systems.

A. DSS OVERVIEW

Keen and Scott Morton [Ref. 3: pp. 11] state that the concept of decision support is based on a balance between human judgement and computer replacement. A DSS supports rather than replaces managerial judgement. It is a formalized method (system) that assists managers in making

effective decisions for semi-structured and unstructured problems. Effectiveness involves identifying what should be done and ensuring that the chosen criterion is the relevant one.

Primary facilities of a DSS are models and a database. Models may be either descriptive or normative. By their very nature models apply more to semi-structured decisions than unstructured ones. To create a model of a problem requires that the problem possesses some structure. Once the model has been defined, data may be input into the model to produce a range of alternatives for managerial evaluation.

Unstructured problems may be broken down into a series of subproblems of which some may be modelled as semi-structured problems. Those subproblems that cannot be modelled require the availability of relevant information from which the manager may make situational value judgements. Such information may be obtained from staff and technical advisors, past managerial experience, and the corporate database. Retrieval of information from an automated database requires some type of user-oriented query language, data reduction capability through parameter specification of information to be retrieved, and formatting facilities for presented data, such as a graphical display or a report writer.

The effective design of a DSS depends on the analyst's detailed understanding of management decision processes and

on the manager's clear recognition of the criteria for developing useful computer-based decision aids. Todate this combination of skill requirements has rarely been achieved which accounts in large part for the current operational orientation of MIS design.

B. EFFECT OF COGNITIVE STYLE ON DSS DESIGN

Since a DSS is designed to support managerial judgement, the designer must recognize the decision maker as a unique individual and consider his or her personalized strategies and abilities. This implies that each person has his or her own specialized style of decision making. Incompatability between the decision maker's problem solving habits, strategies, and abilities and the implicit style of the system will generally produce a system that is not used. For this reason a DSS should support the cognitive style of its users.

McKenney and Keen [Ref. 4: pp. 80-81] conducted research on the cognitive style of MBA students at the Harvard School of Business. They examined problem solving and decision making in terms of the processes through which individuals organize the information they perceive in their environment, bringing to bear habits and strategies of thinking. McKenney and Keen classified observed modes of thought along two dimensions--information gathering and evaluation.

Information gathering relates essentially to the perceptual processes by which the mind organizes the stimuli

which it encounters. Information gathering involves rejecting some of the data encountered and summarizing and catagorizing the remainder. Perceptive individuals focus on relationships between items and look for deviations from or conformaties with their expectations. Receptive thinkers focus on detail rather than relationships and try to derive the attributes of information from direct data analysis instead of by fitting it to their precepts.

Information evaluation refers to the processes commonly classified as problem solving. Systematic individuals tend to approach a problem by structuring it in terms of some method which may lead to a possible solution. Intuitive thinkers usually avoid committing themselves to a specific method. Their strategy is more one of solution testing by trial-and-error. They tend to be sensitive to cues that they may not readily be able to identify.

Combining their observations on information gathering and evaluation, McKenney and Keen [Ref. 4: pp 83] developed a model of these cognitive relationships that is presented in Figure 4. The model suggests that there needs to be a fit between the decision maker's cognitive style and the information processing constraints of his or her task. Given this fit, the manager is more likely to gather information that leads to successful problem finding. Also, he or she should be able to evaluate that information in a way which facilitates successful problem solving.

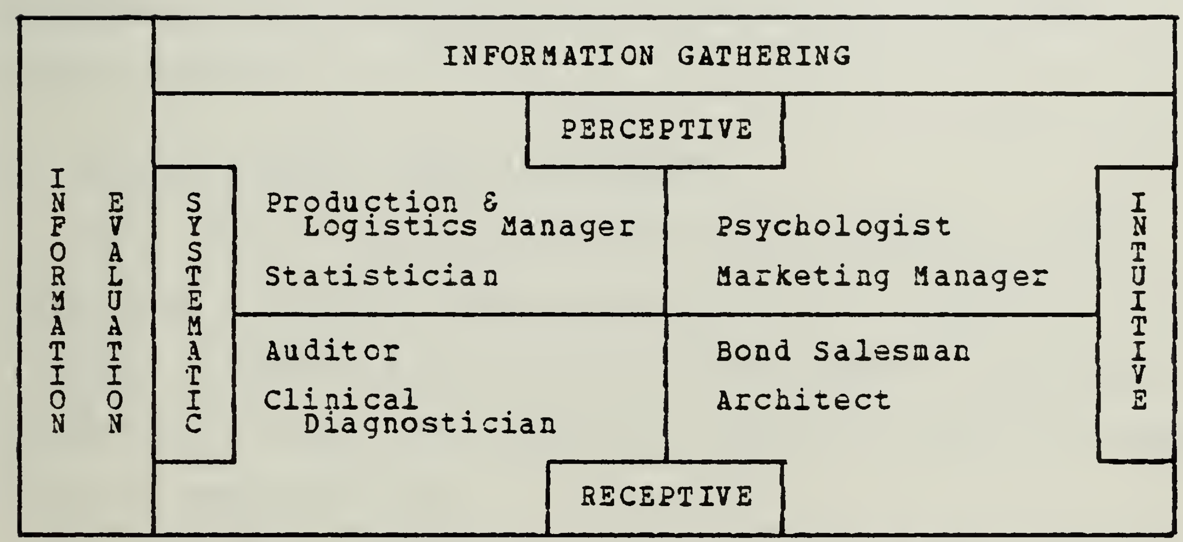

Figure 4: Model of Cognitive Style with Example Roles

In general, computer systems are designed by systematic thinkers for systematic users. This design approach may produce systems which will not be used by all types of managers. For this reason DSS designers must also possess an understanding of the intuitive approach to problem solving and be capable of developing models which will amplify and complement that style of thinking. This implies a need for rich query capabilities and on-line model building facilities with intermediate file storage for trial-and-error results.

C. DESIGN INSIGHT FROM DSS TAXONOMY

Alter [Ref. 5: pp. 41-42] developed a taxonomy of DSS based upon a research study of eight installed systems. His taxonomy catagorizes DSS in terms of the generic operations which they perform. The reasonably distinct types of systems which he identified are:

a) File Drawer Systems - allow immediate access to data items;

b) Data Analysis Systems - allow the manipulation of data by means of operators tailored to the task and setting or operators of a general nature;

c) Analysis Information Systems - provide access to a series of data bases and small models;

d) Accounting Models - calculate the consequences of planned actions based on accounting definitions;

e) Representational Models - estimate the consequences of actions based on models which are partially non-definitional;

f) Optimization Models - provide guidelines for action by generating an optimal solution consistent with a series of constraints; and

g) Suggestion Models - perform mechanical work leading to a specific suggested decision for a fairly structured task.

In Figure 5 Alter [Ref. 5: pp. 42] collapses his taxonomy into a simple dichotomy between data-oriented and model-oriented systems.

Alter [Ref. 5: pp. 54] suggests that his taxonomy could be used in the design of a DSS. He offers that a system designer might attempt to sketch out a system of each type as a potential solution to the system design problem. Then in his or her final design the DSS designer could combine the features of each solution that best serve a given decision maker. Alter's advice is cogent because it recognizes the need for DSS design alternatives which combine both modeling and data handling capabilities to support a variety of cognitive styles.

D. BUILDING MODELS FOR DSS

1. Process of Problem Finding

Pounds [Ref. 6] views a problem as the observed difference between an existing and a desired situation. He identifies the elements of managerial activity as operators. An operator is used to transform a set of input variables into a desired output according to some predetermined plan or model. Pounds states that since problems are defined by

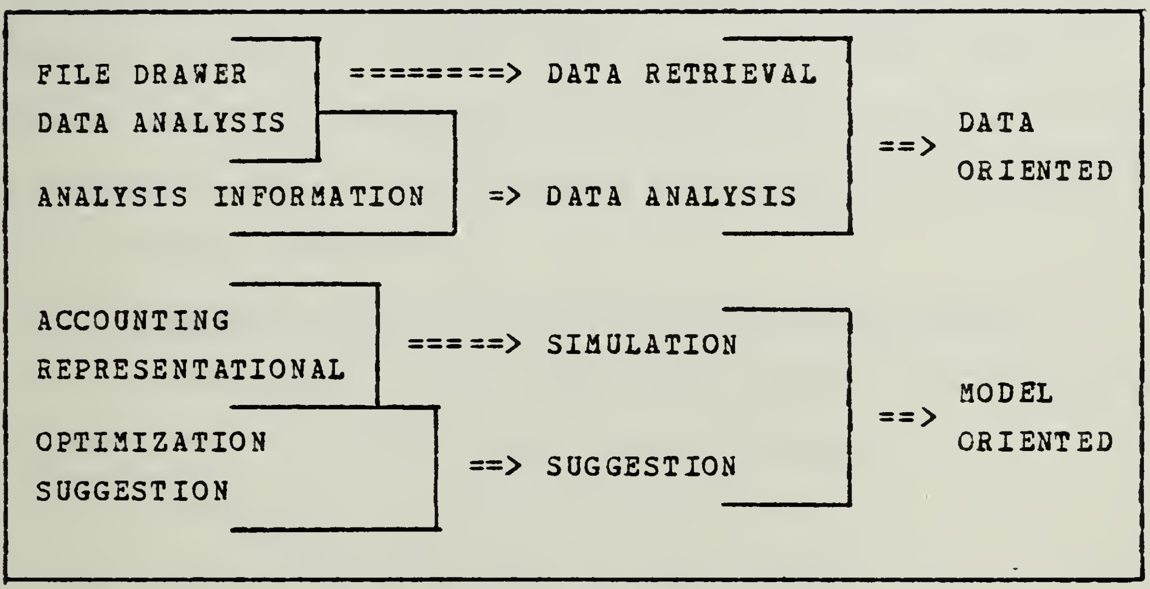

Figure 5: Data-Oriented vs. Model-Oriented DSS Types

differences, and operators are used to reduce these differences, strong associations are formed between problems and operators.

Because operator selection is triggered by the difference to be reduced, the process of problem finding is the process of defining differences. Problem solving is then the process of selecting operators which will reduce these differences. Differences are recognized by comparing what the manager actually perceives in a given situation to the predicted output of a model which he or she would apply to that situation. The problem of understanding problem finding is therefore one of understanding the models which managers use to define differences.

2. <u>Characteristics of Good Decision Making Models</u>

Little [Ref. 7: pp. B467-B468] offers several reasons why models are not more widely used by managers:

a) Good models are hard to find;

b) Good parameterization is even harder;

c) Managers do not understand models; and

d) Most models are incomplete.

Little [Ref. 7: pp. B469-B470] suggests that if a designer wants a manager to use a model, he or she should make the model an extention of the manager's ability to think and to analyze his or her operation. Little believes that good decision making models should be:

a) Simple - simplicity promotes ease of understanding;

b) Robust - it should be difficult for the user to make the model produce bad results;

c) Easy to Control - the model should behave the way that the user wants it to operate;

d) Adaptive - the model should be capable of being updated as new information becomes available;

e) Complete on Important Issues - although completeness is in conflict with simplicity, structures must be found that can handle many phenomena to ensure valid results; and

f) Ease of Communication - the manager should be able to change inputs easily and obtain outputs quickly.

3. <u>Building Models for Decision Makers</u>

Urban [Ref. 8] synthesized the thoughts and ideas of many model builders, incorporating his own experience in modeling. The result of his effort is an overall process of building implementable models as presented in Figure 6.

His methodology is based on a view of modeling as an organizational change process and draws on the study of organizational development. Urban concludes that the model builder may be considered as an organizational change agent. The goal of this process is to improve decision making. The specific tasks in the phases of Urban's model building process are:

a) Formulation of Priors - the model builder should recognize his or her own biases and prior inclinations;

b) Entry - entry into the organization should be made at a decision point; care must be taken to show that the model will supplement and not replace the manager in his or her decision making role;

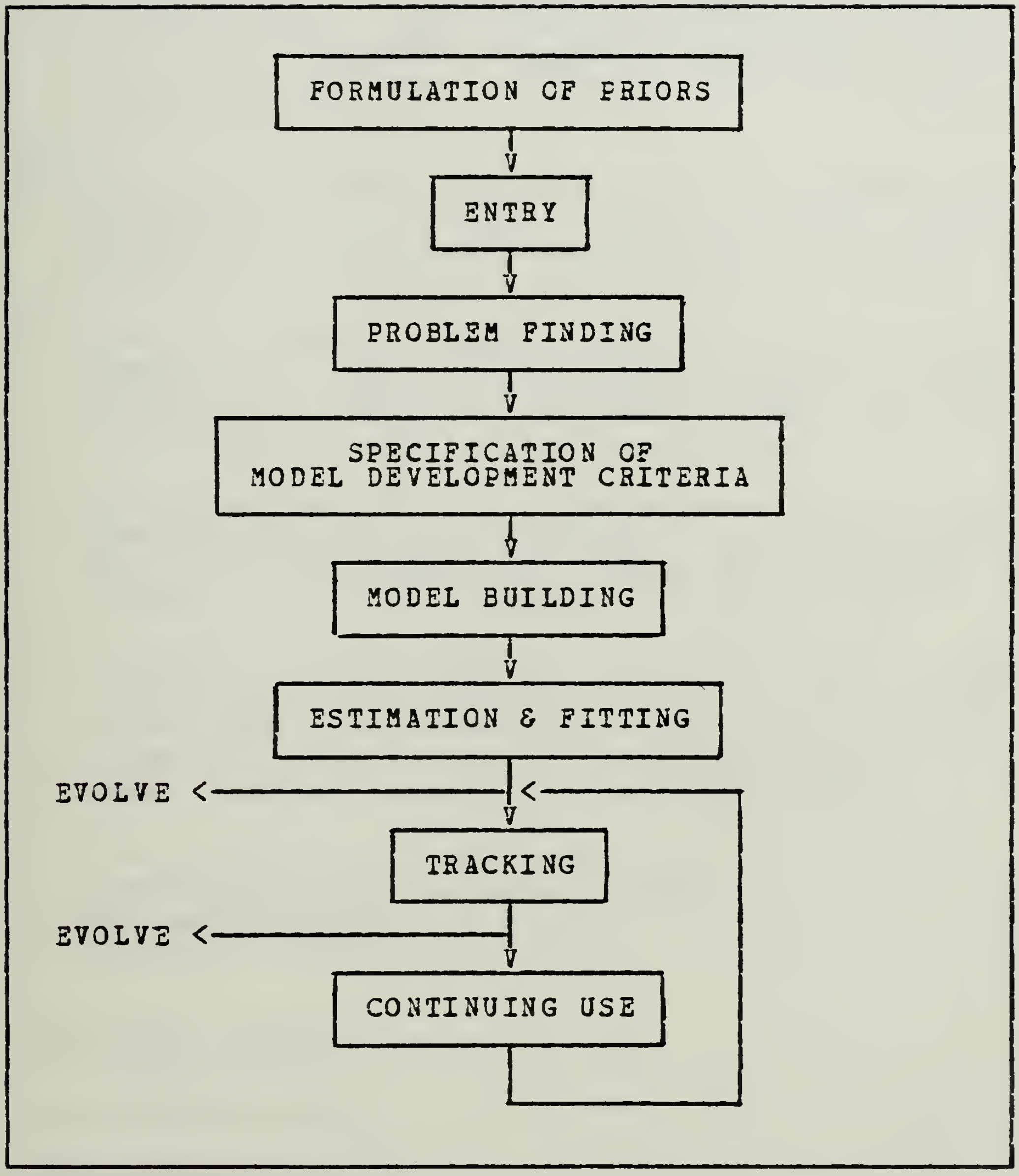

Figure 6: Process of Building Models for Decision Makers

c) Problem Finding - effort should concentrate on the real needs of the organization; studies may be conducted to determine existing models or rules of thumb, the characteristics of decision processes, the existing flow and usage of information, the clientele's behavior and relationship to the organization, the stated and apparent goals of the organization, the information and formal organizational structure, manager's definitions of their perceived problems, and the basic issues underlying current crises;

d) Model Development Criteria - the important factors, phenomena, and variables along with their interactions should be listed and ordered by rank in terms of priority for inclusion in the model;

e) Model Building - several types of models should be produced in rough form and then evaluated by the model builder and manager to determine which one provides the best approach to problem solving;

f) Estimation and Fitting - data for model building may come from subjective judgement, an analysis of past data, or experimentation; given that the model adequately fits these data, it may be used;

g) Tracking - the forecasts of future events predicted by the model are compared to actual results, and differences are reconciled; this implies an evolutionary process in model development in that the model must be "tuned" as conditions change; and

h) Continuing Use - continuing use of a model leads to elaboration and evolution of the model; also, through use models require customizing to meet the needs of specific users.

E. DSS DESIGN PROCESS

Keen and Scott Morton [Ref. 3: pp. 173-187] present a two stage design cycle for DSS--the predesign stage and design stage. Their models emphasize analysis of the decision situation and definition of the criteria for the technical structure contained in the DSS.

1. Predesign Cycle

The primary purpose of the predesign cycle is to ensure that the relevant decision problem is identified. In traditional computer systems analysis this cycle is equivalent to requirements analysis. Keen and Scott Morton's [Ref. 3: pp. 174] framework for the DSS predesign cycle is presented in Figure 7.

The process begins with decision analysis where a potential area for decision support is identified. Problems do not, however, come neatly packaged. Instead, they are usually a symptom of some deficiency or missed opportunity. This implies the need for some type of analytic model by which a problem may be recognized. Unfortunately, few good models are available for this purpose. The lack of such models is the primary reason why most MIS's fail to adequately support managerial decision making. Without models it is difficult to recognize problems that may require support. Consequently, most DSS designs begin by describing the current organizational decision making processes. From the descriptive study key decisions are then identified.

The intent of a decision support system, however, is to improve the effectiveness of managerial decision making. To approach optimality in decision making requires that normative models be defined. Management science has developed a rich supply of normative models for solving

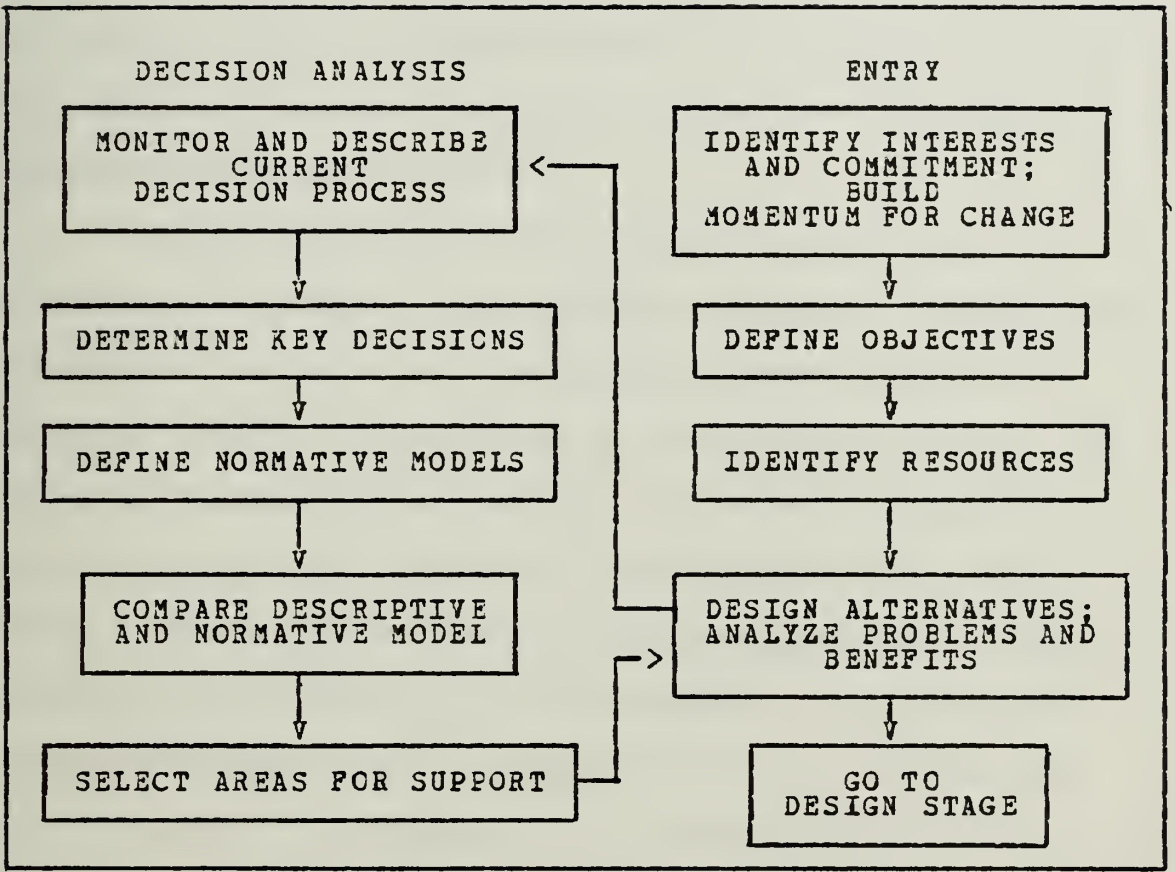

Figure 7: DSS Predesign Cycle

specific problems. By breaking down key decisions into subproblems and clustering related subproblems, the DSS designer might then identify a normative model or group of models that will assist in improving a specific type of decision. By integrating these individual models into a network of normative DSS's the designer would then provide the manager with a managable method for exploring problems and, thereby, increase the effectiveness of his or her decision making performance.

Normative models are important because they are proposals for change. The relative difference between the descriptive analysis and the normative model defines a potential range of designs for an information system. The degree of change represented by this range is generally a measure of both the payoff and the difficulty of implementation. In the process of selecting an approach it must be remembered that managers are individuals. They possess unique cognitive styles. Consequently, not all decision makers evaluate information in a normative manner. The choice of design approach to decision support must be made based on an analysis of the trade-off between risk and return. That choice should be made by the manager, not the DSS designer.

Entry relates to the essential steps in the implementation process--building momentum for change and

developing a contract for action that involves realistic, mutual expectations and commitment among the parties involved. The predesign process may be repeated several times before committing to a specific design strategy.

2. Design Cycle

In the design cycle it is essential to focus on what the DSS is intended to do, not on what it should look like. The design cycle is a combination of the conceptual design and applications specifications phases of traditional computer systems analysis. The Keen and Scott Morton [Ref. 3: pp. 186] framework for the DSS design cycle is presented in Figure 8.

Key questions to ask at the start of the design cycle are:

a) What do we want the DSS to accomplish?

b) How will we recognize when the system has met its design objectives?

c) What are the priorities and/or sequence of stages planned to meet the design aims?

Goals of the system may be defined in the form of imperative commands, such as "plan", "find", "display", and "analyze". In reality the DSS will probably never be truly complete because it will evolve as users and designers move closer to the normative models defined in the predesign cycle: with system experience the tendency is to seek the greater payoff of the normative decision solution. Priorities can be assigned on the basis of user needs and/or

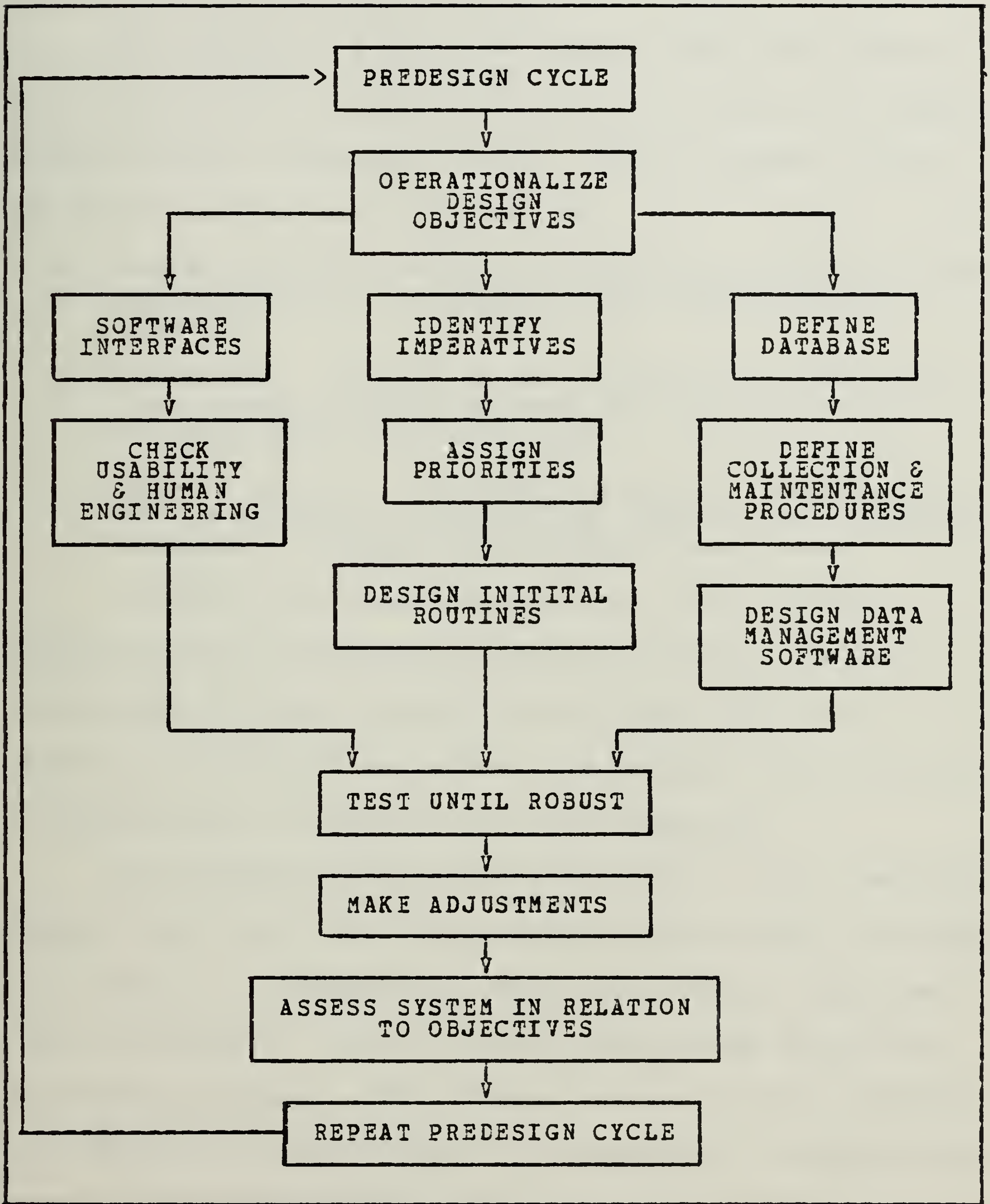

Figure 8: DSS Design Cycle

technical feasibility. Obviously, the user should define the priorities whenever possible.

The design of a DSS involves two additional areas--the software interface, which links the user and the system, and the database management design. Major software issues with which the designer must deal are:

a) Communicability - ease of interaction with the system implying the use of English-like commands where possible;

b) Robustness - ability of the system to prevent users from making mistakes so that the system is both reliable and predictable; and

c) Ease of Control - allowing the users to operate the DSS in their way, not forcing them to use a specific sequence of commands or unnatural vocabulary.

Problems with many DSS's are that they require relatively large databases and complex retrieval facilities with infrequent access to most of the data. Obtaining efficient, cost-effective software to provide these services and maintain data integrity is at best difficult.

An assumption of the DSS philosophy is that competent managers will learn from using the system and begin to extend their analysis. Consequently, they will require additional levels of support. For this reason, DSS design becomes an evolutionary process. The intended result of this iteration is to improve the effectiveness of managerial decision making through experimentation and learning.

In the next chapter a model for decision analysis of strategic planning shall be developed. The model is intended to provide a generalized, normative framework with which to identify strategic information uncertainty when applied to a specific organization.

IV. DECISION ANALYSIS MODEL FOR STRATEGIC PLANNING

A general framework for strategic decision analysis will be developed in this chapter from a combination of economic and organizational theory. To utilize the model one would first perform a descriptive analysis of the firm within the model's parameters. Then the descriptive analysis would be compared with the section of the model that best describes the firm's market structure. Differences between the descriptive analysis and the normative model would identify potential weaknesses of which some might be improved through decision support.

A. FOUNDATIONS OF STRATEGIC DECISION ANALYSIS FRAMEWORK

Strategic planning is routinely identified as an integral part of a well-designed MIS. Although the subject of strategic planning is often discussed in MIS literature, there is a paucity of information concerning the design of such systems. Strategic planning requires extraction and correlation of information from three sources--the environment, the firm's market, and the firm itself. Considering the complexity of developing an effective MIS within the firm, one can readily appreciate the difficulty in designing a global system that interfaces the firm with its environment.

A method of analyzing information requirements for this external interface shall now be presented.

1. Environmental Factors

All firms exist within the somewhat nebulous concept of the environment. Common aspects of this environment are:

a) Consumers - through their desires, preferences, expectations, and political influence, i.e. consumerism;

b) Government - through legislation, taxation, regulation, and monetary policy;

c) Technology - through market opportunities from innovation, effect on optimal plant capacity, and effect on market share; and

d) Market Structure - through the competitive nature of the firm's market, i.e. perfect competition, oligopoly, or monopoly.

The firm must interact with the above environmental factors on a continuing basis. Therefore, policies toward each of these elements must be considered in the firm's strategic plan.

2. Overview of Industrial Analysis

Caves [Ref. 9: pp. 1-2] states that studying the behavior of all business units in the nation at one time is equivalent to studying the whole economy. Studying each unit individually results in losing perspective of a firm's relationship to the economic system. Industrial organization was conceived to split the difference between these two extremes: it examines the market. Individual businesses interact with each other in markets which are defined by a

group of buyers and sellers of a particular product. The sellers participating in a given market are collectively called the industry. The economic study of an industry is termed industrial analysis.

Caves [Ref. 9: pp. 14] offers that the most popular framework for industrial analysis rests on three concepts--market structure, market conduct, and market performance. These elements may be defined as follows:

a) Market Structure - the relatively stable features of the market environment that influence the rivalry among the buyers and sellers within the market;

b) Market Conduct - the policies that participants adopt toward the market with regard to price, product characteristics, and other terms which influence market transactions; and

c) Market Performance - a normative appraisal of the social quality of resource allocation that results from a market's conduct.

The first two aspects of industrial analysis--market structure and market conduct--are of primary importance to the development of a strategic decision analysis framework. They indicate the interaction of the firm with its market through the implementation of specific strategic plans.

3. Elements of Market Structure and Conduct

Caves [Ref. 9: pp. 17-37] defines the key elements of market structure as:

a) Seller Concentration - the number of firms participating in a particular market, i.e. perfect competition, oligopoly, or monopoly;

b) Barriers to Entry - the mechanisms which exclude potential rivals from the market, such as economies of scale, absolute cost barriers, technological advantage, patents, and regulated status; and

c) Product Differentiation - the ability of a manufacturer to distinguish his or her product from those of his or her rivals through advertising, brand name loyalty, and/or specialized maintenance service for durable goods.

Caves [Ref. 9: pp. 50-65] identifies the key elements of market conduct as:

a) Product Policies - the means by which the firm varies the characteristics of its product to compete with its rivals; the aim of these policies is to achieve product differentiation;

b) Pricing Policies - price structures that are generally determined by seller concentration of the market, i.e. price equals marginal cost (P = MC) for perfect competition coordinated pricing for oligopolies, and marginal revenue equals marginal cost (MR = MC) for monopolies and others who seek to maximize profits; and

c) Policies toward Rivals - those actions which a firm takes to minimize both its actual and potential competition.

It should be noted that product and pricing policies are greatly influenced by the seller concentration of the market. By definition a perfectly competitive market is one in which the seller has little effect on his or her market share. Under perfect competition product and pricing policies are normally determined by market conditions rather than by the seller. In highly concentrated markets, such as oligopolies and monopolies, the seller may have considerable impact through his or her policy implementation. Pricing and product flexibility exist only when the degree of competition

from rivals is reduced, implying reduced substitutability, and/or when product differentiation exists, implying an environment of imperfect consumer information.

Market structure may be viewed as a subset of the environment in which the firm choses to operate. Goals and objectives must be formulated to effectively deal with market structure if the firm desires to either maintain or improve its market share. Market conduct represents the goal processing mechanisms by which the firm achieves its strategic objectives. Study of these interacting factors is essential to the development of a strategic decision analysis model.

4. Overview of Firm Strategy and Structure

Galbraith and Nathanson [Ref. 10: pp. 3] define strategy as the choice of a specific action or set of actions to meet specific goals. Strategy initiates goals when a business begins operation and modifies goals as a business matures. Changes of strategy result from an awareness of opportunities and needs within the firm's environment or market. This contention implies that the firm must continually scan its environment and evaluate its current goal processing mechanisms--market conduct--in view of its business success in the market that it has chosen to enter. Since most markets are dynamic, the need for this evaluation should prove to be an iterative process.

Galbraith and Nathanson [Ref. 10: pp. 306] discuss the research of Alfred Chandler in understanding firm strategy. In his book Strategy and Structure Chandler distinguishes certain key growth strategies that are important in ensuring the long-term survival of an organization. These strategies are:

a) Expansion of Volume,

b) Geographic Dispersion,

c) Vertical Integration, and

d) Product Differentiation.

Chandler demonstrated how each strategy tended to pose a different type of administrative difficulty which required a different form of organizational structure. If leadership within the current firm structure is incapable of forming and implementing needed strategy changes, a strategy-structure mismatch will occur requiring a change of organizational form. This process of adjustment implies a bidirectional fit between strategy formation and firm structure. Once a viable organizational form exists to implement an appropriate strategy, the firm will then be in a position to impact upon its environment. Inability to adapt to its environment will cause the firm to stagnate and decline. This sequence of events indicates that firm structure follows strategy formation through the process of fit. The manifestation of this process is then the firm's market conduct.

5. Firm Strategy and Structure Relationships

Miles and Snow [Ref. 11: p. 548-550] developed a general model of strategic choice which they term the adaptive cycle. They believe that organizational behavior is only partially preordained by environmental conditions and that the strategic choices which a firm's management makes are the critical determinants of organizational structure and process. They reduce the potential range of choices to the following broad patterns of organizational adaptation:

a) Entrepreneurial Problem - defining a specific good or service to offer in a target market or market segment, i.e. domain;

b) Engineering Problem - making operational top management's solution to the entrepreneurial problem; and

c) Administrative Problem - rationalizing and stabilizing those activities which have successfully solved problems faced by the firm during the reduction of uncertainty, and formulating and implementing those processes which enable the firm to continue to evolve, i.e. innovation.

As firms move through the adaptive cycle of strategic choice, they must select specific strategies to solve their entrepreneurial, engineering, and administrative problems. Miles and Snow [Ref. 11: pp. 550-558] identify the following strategic typologies:

a) Defenders - deliberately enact and maintain an environment for which a stable form of organization is appropriate; strive aggressively within their domain to prevent competitors from entering their "turf"; tend to ignore developments and trends outside of their domain, choosing instead to grow through market penetration and perhaps some limited product

development; over time carve out and maintain a small niche within the industry which is difficult for competitors to penetrate;

b) Prospectors - respond in many ways to their chosen domains in a manner that is almost the opposite of the Defender; enact an environment that is highly dynamic by finding and exploiting new product and market opportunities; must develop and maintain the capacity to survey a wide range of environmental conditions, trends, and events by investing heavily in scanning groups and mechanisms; utilize change as a major tool to gain an edge over competitors;

c) Analyzers - combine the characteristics of the Prospector and Defender and represent a viable alternative between these two extremes of strategy; attempt to minimize risk while maximizing the opportunity for profit through a balanced adaptive approach; and

d) Reactors - exhibit a pattern of adjustment to their environment that is both inconsistent and unstable; lack response mechanisms which they can consistently put into effect when faced with a change of environment.

Miles and Snow [Ref. 11: pp. 558-561] find that, in general, traditional and human relations managerial beliefs are more likely to be found in Defender and Reactor organizations while human resources beliefs are more often associated with Analyzer and Prospector organizations. The traditional management model maintains that the capability for effective decision making is narrowly distributed in the organization, and this approach legitimizes unilateral control of organizational systems by top management. The human relations model accepts the traditional notion that superior decision making competence rests with a select few among the employee population but emphasizes the social needs for belonging

and recognition. Both of these philosophies imply a highly centralized, functional management structure. The human resources model argues that the capacity for effective decision making in pursuit of an organization's objectives is widely dispersed. It further believes that most employees represent untapped resources which, if properly managed, could considerably enhance organizational performance. The human resources approach views the role of management not as that of a controller but as that of a facilitator. This approach to management philosophy suggests a decentralized structure.

B. RELATIONSHIPS OF STRUCTURE, STRATEGY, AND CONDUCT

Synthesizing the previous discussion one may view the flow of structure, strategy, and conduct relationships as modelled in Figure 9. The model suggests that the total economic environment influences a particular market structure. The specific market structure in which the firm operates and the total economic environment interact to determine the firm strategy needed to sustain operation within those spheres of influence. Appropriate fit--the ability to implement that requisite strategy--specifies the firm structure that is necessary to conduct business within the firm's chosen market. Market conduct represents the manifestation of a responsive strategy within the adaptive cycle of strategic choice. Through the outputs and

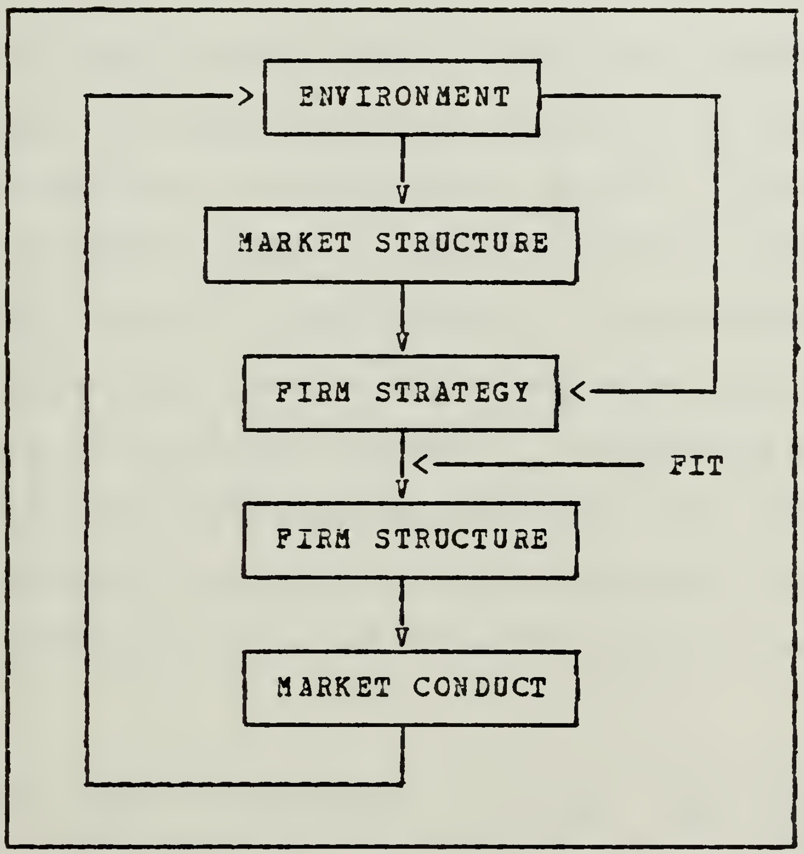

Figure 9: Flow Model of Structure, Strategy, and Conduct

influences of its market conduct the firm, then in turn, impacts upon the economic environment.

The flow model of Figure 9 may be collapsed into a dichotomy of strategic relationships as exhibited in Figure 10. Figure 10 suggests that the strategic plans of a firm must deal with two levels of interacting forces--the larger economic environment and a subset of that environment, the firm's market. To remain managable, however, it should focus on strategic decisions concerning its market. While environmental issues, such as consumer markets, government, and technology, must be considered on an ongoing basis, these data-intensive issues would be addressed more reasonably by means of an ad hoc approach. By employing a market-oriented strategic planning model the firm could split the difference between the unwieldy task of trying to monitor the entire economic system and of performing no strategic planning.

C. NORMATIVE MODEL OF STRUCTURE, STRATEGY, AND CONDUCT

The model in Figure 11 indicates the expected relationship of specific elements of structure, strategy, and conduct for major economic market structures. To utilize this model a DSS designer would first perform a descriptive analysis of each element of the model for a given firm. Based upon the seller concentration of the market in which the firm operates, the designer would enter the appropriate

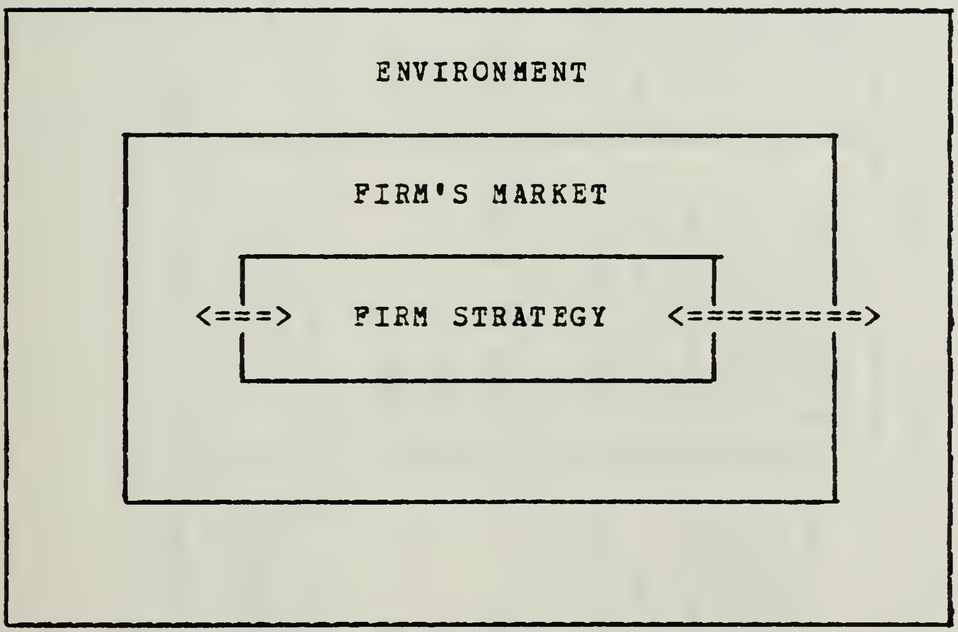

Figure 10: Model of Strategic Relationships

	ENTER BASED ON SELLER CONCENTRATION		
	PERFECT COMPETITOR	OLIGOPOLIST	MONOPOLIST
MARKET STRUCTURE:			
Concentration	Low	High	One
Entry Barriers	Few	Many	Many
Differentiation	None	Some to Much	High
MARKET CONDUCT:			
Product Policy	Penetrate	Fair Share	Differentiate
Price Policy	P = MC	Coordinated	MR = MC
Rival Policy	Defensive	Cooperative	Erect Barrier
FIRM STRATEGY	Defender; Reactor	Prospector; Analyzer	Prospector; Analyzer
FIRM STRUCTURE	Functional	Functional; Decentralized	Functional; Decentralized

Figure 11: Normative Model of Structure, Strategy, and Conduct

column of the normative model. He or she would then identify potential problem areas in current firm strategy by observing differences between actual and normative conditions. Having identified differences the designer would then separate these differences into two catagories--those caused by information uncertainty and those caused by strategy-structure mismatches. A DSS may potentially be developed to resolve problems arising from information uncertainty but cannot deal with the need for organizational change identified by strategy-structure mismatches. These mismatches may only be resolved by restructuring the organizational form.

With information-related strategic differences now identified the DSS designer would then consult with top management to develop a series of alternative models that might be used to reduce strategic information uncertainty. Top management then could assess the trade-off between risk and return for each alternative and select the most viable alternative. The selected approach would then proceed to the DSS design stage.

The above normative model will be used in the following chapter to analyze strategic information requirements for military medical food service. Findings of this analysis, that are caused by information uncertainty, will then identify requirements for strategic decision support in the design of the TRI-Food MIS.

V. REQUIREMENTS ANALYSIS FOR TRI-FOOD DSS

The decision analysis model developed in the previous chapter will now be used to investigate the need for specific TRI-Food DSS's. The Keen and Scott Morton predesign cycle model will be used as the methodology for performing this requirements analysis. First, a descriptive analysis of the strategic decision analysis model's parameters shall be performed. Then this analysis shall be compared to the expectations of the strategic decision analysis model to identify differences that may be reduced by decision support.

A. ENVIRONMENTAL INFLUENCES

1. Consumer Expectations

The consumer market of military medical facilities consists of active duty military personnel, retired military personnel, and their dependents. In a medical treatment environment these groups may be further subdivided into inpatients, outpatients, and medical facility staff members.

Food service supports these consumer groups through both administrative and clinical functions. Administrative functions include providing meal service to medical staff members, inpatients, and certain authorized catagories of outpatients. A hospital mess is not a general mess in that its facilities are not available to all catagories of military

personnel. It provides meal service by two quite different methods--cafeteria service and patient tray service to nursing units.

In addition to its administrative responsibilities, food service offers a variety of nutrition-related services to both the inpatient and outpatient MTF population. Typical nutritional services include therapeutic diet preparation, personal counselling of inpatients as to their therapeutic regimen, outpatient counselling as referred by physicians, and inservice training for medical staff in various aspects of nutrition.

Reasonable expectations of these consumers might include:

a) Professional guidance in nutritional care;

b) High quality, nutritious meal service offered in a clean, pleasant atmosphere at a reasonable cost;

c) Easy access to scheduled cafeteria service; and

d) Timely, personalized response to the meal service needs of inpatients restricted to nursing units.

2. <u>Changes in Industry Technology</u>

Traditionally, service industries, including food service, have proven to be very labor intensive. In recent years equipment manufacturers and facilities designers have begun to address the problem of rising labor costs in food service operations. A major advance in attempting to minimize the cost of labor has been the concept of "ready foods". The "ready foods" program applies a mass production

technique to foods that are conducive to pre-preparation and freezing. Frozen foods are then heated to serving temperature when required for service. This approach provides economies of scale in food preparation by more efficient use of high labor rate food production personnel on one manufacturing shift, instead of the two shift operation of traditional hospital feeding.

While the technology of "ready foods" is not new or conceptually difficult to understand, it has not been adopted in many military medical food service facilities. Notable exceptions to this general rule are the Walter Reed Army Medical Center and the National Naval Medical Center. Perhaps the chief impediment to more widespread use of the "ready foods" concept is the problem of logistics support. The program requires the use of manufacturing principles which are not commonly understood by the institutional food service industry, such as material requirements flow to support the manufacture of products for inventory and accounting for the cost of semi-finished goods. For this reason most military medical food service facilities continue to produce menu items for immediate consumption.

Other topics of technological interest might include the following areas:

a) Availability of commercially prepared foods,

b) Energy efficient equipment,

c) Automated food production and serving equipment,

d) Improved nutrient databases, and

e) Automated administrative and clinical systems.

3. Government Influences

While one would probably not identify government influence as a major strategic issue for one of its own components, there are two influences which do warrant discussion--the regulated status of the operation and the impact of Office of Management and Budget Circular A-76 (OMB A-76). In essence, the military is a regulated industry. It enjoys a regulated status within the defense market. This status has served as a barrier to entry in both tactical and support functions. For this reason the military might be thought of as a monopolist within the domain of defense. As a subset of that industry, military medical food service might also be termed a monopolist.

OMB A-76, first issued on August 30, 1967, establishes procedures to determine whether needed commercial or industrial-type work should be performed in-house using government facilities or by contract with private sources. The Circular was revised and reissued on April 5, 1979. In addition to its previously stated policies, the revised OMB A-76 [Ref. 12] includes a comprehensive Cost Comparison Handbook which details cost accounting methods to be used in developing the true cost of specific work centers, including food service.

The intent of the Circular is to implement a method by which the cost of government provided support services might be compared with bid quotations of commercial vendors for similar work. If the commercial vendor's quotation is less than the cost of the government service, that in-house service may be considered for contracting out. In effect, OMB A-76 will serve to reduce barriers to entry into a specific set of heretofore regulated government functions. This situation should have a major impact on the market structure of those entities subject to its review. For this reason, the effect of OMB A-76 is of strategic importance to those identified entities, including food service.

B. MARKET STRUCTURE

1. Seller Concentration

Military medical food service may be thought of as a group of monopolists operating in specific sectors of the military market, i.e. Army, Navy, and Air Force. Each Service is supported by its own Medical Department, and each Department maintains its own food service program. Consequently, military medical food service could be considered a highly concentrated, multiplant industry.

2. Barriers to Entry

The primary barrier to entry of the military medical food service market is the regulated status of the industry. As noted, however, turbulence is now being introduced in

that market structure by OMB A-76. An additional barrier to entry is subsidized operating cost. Reimbursement for food service is structured only to recover the cost of food; all other operating costs are subsized by government funding. Food items may be procured through government supply depots at a substantial savings when compared to the commercial food market. This cost advantage serves as a further barrier to entry.

3. Product Differentiation

Although it is difficult to differentiate prepared food products, military medical food service attempts to achieve this goal by two mechanisms--variety of menu service and quality of food items. Most facilities offer a highly selective menu service in an effort to reduce menu fatigue. Menu service ranges from short-order items (fast foods) to traditional foods. Generally, food quality is considered good when compared to commercial facilities with the same price structure. Also, operations tend to capitalize on the image of "a member of the military team".

C. MARKET CONDUCT

1. Product Policy

The product policy of military medical food service focuses on the mechanisms that tend to differentiate its product--variety of menu service and quality of food items. These policies, for the most part, continue to maintain the

consumer base within its market. Also, efforts are underway to expand nutritional support in the area of outpatient clinical services.

2. Price Policy

Food service is offered at a fixed price that recovers the cost of food. In economic terms this policy translates to price equals marginal cost of food (P = MC of Food). There are, however, a few facilities which are experimenting with *a la carte* menu pricing, but even prices under this system are structured only to recover the cost of food, i.e. P = MC of Food.

3. Policy toward Rivals

Military medical food service possesses little direct authority to formulate policies toward rivals. Policy formulation is determined by higher authority, such as the three Medical Departments, their parent Military Departments, and the Department of Defense.

D. FIRM STRATEGY

1. Adaptive Cycle of Strategic Choice

The entrepreneurial domain of military medical food service is defined by its agency mission as service of food to authorized patrons and nutritional support. Its engineering problem then becomes to make these objectives operational which is accomplished principally by employing traditional institutional food service methods and standard

clinical practices. The administrative problem of food service focuses on cost-efficient operation within its entrepreneurial domain.

2. Strategic Typology

Military medical food service may be characterized as a Defender. It typically attempts to protect its domain and exhibits only minimal product development.

E. FIRM STRUCTURE

At the Medical Department level food service organizational structure varies by Service. The Army maintains a staff office at the Pentagon. The Navy employs a dual role as a line chief of service at the National Naval Medical Center with staff advisory responsibilities to its Bureau. The Air Force also maintains a staff status at the agency level with the incumbent located at Malcolm Grow USAF Medical Center. Therefore, the Army and Air Force exhibit centralized management structures, and the Navy demonstrates a more decentralized structure.

F. STRATEGIC DECISION ANALYSIS

1. Market-Oriented Decisions

Strategic market-oriented decisions that should be of concern to military medical food service are:

a) How to best use its sanctioned monopoly status, i.e. reduce competitive turbulence;

b) How to ensure continued variety of high quality menu service, i.e. maintain product differentiation; and

c) How to improve its consumer service image, i.e. increase product differentiation.

2. Environment-Oriented Decisions

Strategic environment-oriented decisions that should be of concern to military medical food service are:

a) How to address OMB A-76, i.e. threat assessment and risk management;

b) How to best employ new technologies, i.e. increase cost-effectiveness and operating efficiency by introducing innovative technologies; and

c) How to best serve consumer needs, i.e. achieve consumer goodwill thereby differentiating its product.

G. COMPARISON OF DESCRIPTIVE AND NORMATIVE MODELS

The preceding descriptive analysis will be compared with the normative strategic decision analysis model presented in the previous chapter as Figure 11. The normative model shall be entered under a monopolistic market structure. The descriptive and normative comparison is presented as Figure 12.

H. VARIANCES BETWEEN DESCRIPTIVE AND NORMATIVE MODELS

1. Barriers to Entry

While military medical food service does possess several significant barriers to entry, these barriers are highly vulnerable. Neither barrier--sanctioned status or funding subsidy--is under the direct control of the operating entity. This suggests the need to create barriers directly

	DESCRIPTIVE MODEL	NORMATIVE MODEL
MARKET STRUCTURE:		
Concentration	One per Service	One
Entry Barriers	Sanctioned Monopoly Government Subsidy	Many
Differentiation	Menu Variety Quality of Service "Team Member" Image	High
MARKET CONDUCT:		
Product Policy	Full Service Menus Quality Service	Differentiate
Price Policy	P = MC of Food	MR = MC
Rival Policy	Maintain Barriers	Erect Barriers
FIRM STRATEGY	Defender	Prospector; Analyzer
FIRM STRUCTURE	Functional - Army & Air Force Decentralized - Navy	Functional; Decentralized

Figure 12: Comparison of Descriptive and Normative Models

controlled by food service managers. Flexible barriers to entry are required to allow food service managers to implement policies toward rivals that will preserve their current monopolistic market structure.

2. Price Policy

A major difference identified by the comparison is in the element of price policy. Military medical food service appears to behave more as a perfect competitor than as a monopolist. Using the monopolistic price policy of marginal revenue equals marginal cost might encourage a profit center, instead of cost center, operating philosophy. This policy change would, perhaps, lead to a more cost-effective operation by introducing a greater market orientation. Also, as a monopolist food service could apply limit pricing--a price level which is somewhat below the price level that would maximize profits and foregoes profits in the short term. Limit pricing is frequently used by concentrated industries as a barrier to entry.

3. Firm Strategy

Military medical food service has a well-defined entrepreneurial domain. It emphasizes traditional methods of operation and focuses its administrative efforts on cost-efficiency. These characteristics indicate a Defender strategic typology. Such a typology is inappropriate for a monopolist. To sustain a monopoly a firm must effectively

neutralize its competition by both active and somewhat aggressive market conduct. This suggests the need for either a Prospector or Analyzer strategic typology. The transition to either of these typologies might be accomplished by innovative policy formulation that addresses the previously identified market and environment-oriented strategic issues.

I. DEFINITION OF AREAS FOR DSS SUPPORT

1. Variances Due to Strategy-Structure Mismatch

Variances due to mismatches may not be resolved by implementing DSS concepts. These strategic variances must be corrected by organizational restructuring or policy revision. Mismatches identified include:

a) Barriers to Entry - barriers to entry are essentially determined by groups other than the operating entity; and

b) Price Policy - there does exist pricing flexibility at the Medical Department level; this is evidenced by the testing of a la carte menu prices at certain food service operations; reorientation of pricing policies seems to be a viable opportunity to create a potential barrier to entry through limit pricing.

2. Variances Due to Information Uncertainty

Variances due to information uncertainty may be reduced through effective DSS design. The primary areas of information uncertainty identified include:

a) Inability to Explore Strategic Alternatives - this situation arises from a lack of information processing support for trade-off analysis; there appears to be a need for simulation and/or optimization capabilities to support decision making in this area; and

b) Program Planning and Monitoring - to cope with the threat of OMB A-76, systems must be developed that facilitate program planning and control; by employing cost accounting techniques and budgeting principles food service managers could create operating standards by which to compare their performance with that of commercial firms; this implies the need for budget planning and programming models with mechanisms for variance analysis.

3. DSS Design Criteria

In summary, key strategic issues to be addressed by food service DSS's are:

a) Monitoring of Medical Department performance in relation to commercial contractors through budgeting, standards, and variance analysis;

b) Ensuring product differentiation by preserving the ability to provide full service menus and maintain service image through budgeting, standards, and variance analysis;

c) Compliance with OMB A-76 and use of the resultant managerial accounting information to develop forecasts, budgets, and standards;

d) Ability to perform "what if" analysis to assist in developing programs responsive to the threat of OMB A-76 though planning and simulation of proposed systems;

e) Methods for assessing the value of introducing new technologies through production process scheduling, capacity planning, and system simulation for analysis of the trade-off between cost and performance of investigated systems; and

f) Incremental budget planning and programming systems to ensure adequate funding to meet consumer demands for service through trend analysis of demand, long-range forecasting, budget planning, and budget programming for inclusion in the Program Objective Memoranda of the Service.

The next chapter will examine alternative approaches to the design of DSS's for the above strategic issues. Also,

it shall be shown how suggested support systems may be extended to assist in monitoring the performance of food service operations. Then a DSS network concept shall be proposed for the TRI-Food MIS which will provide an integrated system of decision support.

VI. TRI-FOOD DSS DESIGN ALTERNATIVES

Having identified tasks that require decision support, the final step in the DSS predesign cycle is the investigation of alternate approaches to implementing a support system. Since any TRI-Food DSS must interface with an automated MIS environment, the search for alternatives should focus on automated solutions. This narrowing of alternatives suggests searching for software that supports food service decision making.

This chapter will explore software techniques that might be useful in the design of food service DSS's. Also, it will indicate how some of these software systems might be extended to assist in monitoring performance standards. Finally, a model shall be presented that illustrates a network of food service DSS requirements for an integrated system of decision support.

A. SELECTING AN APPROACH TO SOFTWARE DEVELOPMENT

In general, one may select either of two alternatives in software development--custom software design or purchase of existing applications packages. Both methods offer a range of advantages and disadvantages.

1. Custom Design

Advantages of selecting the custom design approach include:

a) Meets the specific needs of the user;

b) Allows one to utilize currently owned software modules that support other functions for a lower development cost;

c) Costs less to proliferate the system after initial software development; and

d) Offers an atmosphere of creativity by providing the means to explore alternative design strategies, i.e. innovation.

Disadvantages of selecting the custom design approach include:

a) Increases the risk of developing a successful system because design costs may only be estimated at the start of the development cycle;

b) Often results in a long lead time before system implementation, especially for large, complex projects;

c) If performed in house, requires a high ongoing investment to assemble a team of competent applications programmers and hardware for designing and testing software;

d) Places the responsibility for software maintenance on the user which may require maintaining an in-house programming staff to accomodate changes; and

e) Provides less flexibility for change as development proceeds because of the high cost of reiterating the process late in the development cycle.

2. <u>Applications Packages</u>

Advantages of selecting the applications package approach include:

a) Allows the user to see the performance of the system before committing funds to a specific design package;

b) Decreases the initial cost of software development since the developer amortizes his or her cost over many buyers;

c) Decreases the risk of developing a successful system because the design cost may be more accurately determined at the start of the development cycle;

d) Provides the user better documentation since it may have been professionally written by a technical writer;

e) Encourages modular growth of the system since most vendors offer software enhancements that interface with their basic systems; and

f) Contains design logic that is usually developed by a programming specialist for a particular field of applications software, i.e. inventory, accounting, and order entry systems.

Disadvantages of selecting the applications package approach include:

a) Frequently results in the purchase of a highly generalized system that may not satisify all aspects of the user's requirements;

b) Increases the cost of proliferating the system because additional copies must be purchased for each new installation;

c) Requires that the user maintain an ongoing relationship with a specific vendor to support enhancements and maintenance of the purchased system; and

d) Limits the variety of hardware that the user may select because most applications packages are designed to operate on a narrow range of hardware systems.

3. Selecting an Approach

Automated systems are not commonly used in military medical food service operations. The only real experience which most military food service managers have had with computers is in the area of inventory management. These systems, however, are not their systems. Inventory systems

have been designed primarily to support the accountability requirements of supply and financial systems. An exception to this general rule is the Army Medical Department which has developed automated systems to support several of its large food service operations--the Army Medical Department Automatic Data Processing System for Hospital Food Services (AMEDD) and the Army Medical Department Food and Nutrition System (FANS). In general, however, military medical food service may be considered an unsophisticated, limited user of data processing resources and techniques.

To embark upon a major computerization effort that will include the development of a potentially complex MIS, implies a high degree of risk considering the current level of user sophistication. Adding to this design project the need for DSS's further reduces the probability of a successful design effort. To create an integrated, effective MIS, however, requires that all system requirements be considered at the start of the design project. Only through this top-down approach can the user be assured that the system modules will function cohesively when fully implemented. In view of the scope of effort and experience of its users with automated systems, it is suggested that, as an initial approach, the use of known software applications packages should be pursued for TRI-Food. This approach, with its reduced risk, offers the greatest potential for a successful system implementation.

B. FOOD SERVICE SOFTWARE APPLICATIONS PACKAGES

A review of available food service software will now be conducted to determine if software applications packages exist that will satisfy the requirements for TRI-Food DSS's. Systems will be examined from two points of view--food service management systems and normative decision support. Then an analysis of available systems shall be provided.

1. Food Service Management Systems

Schuster [Ref. 13] offers a compendium of the current types and features of commercially available food service software applications. Her summary describes twenty-one systems that are supplied by sixteen vendors. Applications include such functional modules as:

a) Recipe and Menu Costing,

b) Forecasting,

c) Production Scheduling,

d) Purchasing Requirements,

e) Labor and Food Cost Control,

f) Inventory Management,

g) Menu Planning,

h) Nutritional Analysis,

i) Nutritional Assessment,

j) Patient Education, and

k) Patient Menu Tallying.

The above functions are designed primarily to support structured food service operational control decisions. Some structured management control support is provided in the form of cost reports and nutritional analysis of menus. None of the food service systems provided direct support for strategic planning.

2. Normative Decision Support

Normative models for food service operations are sparse. The best known, and perhaps only, normative model specifically designed for food service is Dr. Joseph Balintfy's menu cost programming system. Balintfy [Ref. 14] describes his system as a multistage, multiple choice programming system that was developed to reduce the menu cost of institutional food service programs by computer assisted menu planning. The software system supporting this concept is titled Computer Assisted Menu Planning (CAMP).

CAMP is a zero-one variable, multiple choice integer program. It applies the technique of integer programming to a system of constraints that include nutrition, structure, attribute, and separation factors commonly considered in menu planning. The objective of the problem formulation is to minimize menu cost within the parameter constraints. Integer programming is a very powerful mathematical tool that is used to solve problems where some or all of the variables

in the optimal solution must be non-negative whole numbers. Balintfy applies this technique as a normative approach to menu planning.

What Balintfy has created is, perhaps, the first true food service DSS. CAMP focuses on a specific, semi-structured food service problem and attempts to solve that problem by a normative model. Although CAMP is not a comprehensive system of decision support, this system may be considered as a potential DSS for menu planning.

3. Conclusions Concerning Food Service Software

Of those systems surveyed, no one vendor offers what might be considered a complete food service MIS within the framework of TRI-Food requirements. Although there are elements of such a system that focus on operational control and some aspects of management control, the fact that a comprehensive food service system with both MIS and DSS potential does not exist suggests the need to broaden the scope of search for software systems.

C. PARALLELISM BETWEEN FOOD SERVICE AND MANUFACTURING

Buffa [Ref. 15: pp. 6-7] defines a productive system as the means by which resource inputs are transformed into useful goods and services. He models this concept as shown in Figure 13. Buffa states that resource inputs may assume a wide variety of forms. The relative weight of these inputs is dependent upon the nature of the industry.

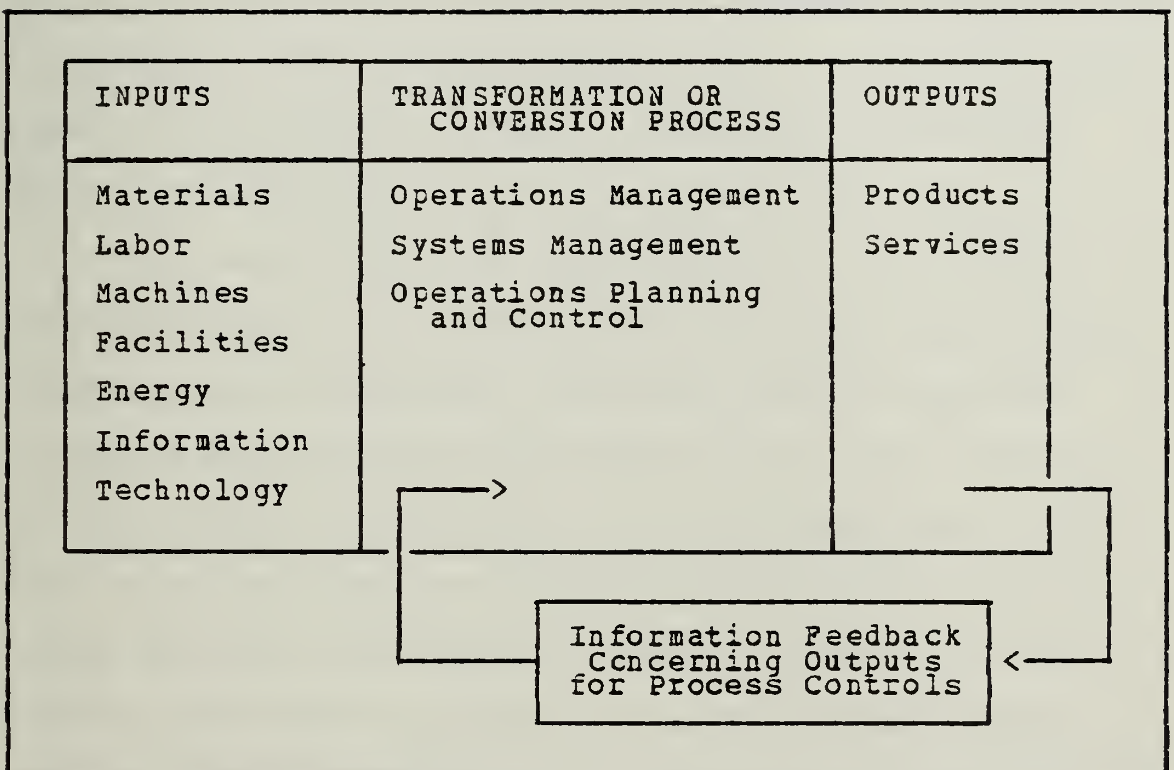

Figure 13: Model of a Productive System

Manufacturing operations are generally dominated by raw materials while service-oriented operations require a heavy investment in labor. The conversion process involves both the application of technology and the adroit management of all input resources. He finds that the essence of management is to comprehend the interrelationship of all variables and to view the entire system as an integrated process insofar as possible. The result of managerial effort is then the output of products and services which meet the consumer market's standards for quality, quantity, and cost.

In the Burger Case, Buffa [Ref. 15: pp. 8-18] illustrates how his productive systems concept and production/operations management principles might be applied to the successful design and expansion of a food service system. Buffa describes how an entrepreneur opens a fast food restaurant that specializes in hamburgers. As sales volume increases, the owner is faced with many critical business decisions to satisfy the growing demand for his service. Buffa demonstrates the application of manufacturing principles in managing the process of expansion, such as product design and costing, equipment configuration, capacity planning, material warehousing and distribution, forecasting, and strategic planning. This insight suggests the next area of search for food service software support--manufacturing systems.

D. ADVANTAGES OF A MANUFACTURING APPROACH

1. Well-Established System Techniques

Buffa [Ref. 15: pp. 2] states that there are many reasons to adopt a manufacturing approach to management. Manufacturing systems have been the focus of attention of management scientists since the early 1900's. Manufacturing has developed a wealth of knowledge, systems experience, and management techniques that deal with forecasting, design, layout, job analysis, automation, scheduling models, inventory models, statistical quality control, computers, simulation models, waiting line models, and mathematical programming, In other words, manufacturing processes are well understood by both systems analysts and software designers.

2. Availability of Manufacturing Software

The number of vendors who market software applications that support manufacturing functions is quite large, and the variety of such packages is extensive. Snyders [Ref. 16] offers a directory of independent software vendors who supply general business applications. Her summary identifies 187 vendors who offer the following software applications that are of interest to manufacturing firms:

a) Accounting,

b) Database Management,

c) Financial Management,

d) Inventory Control,

e) Manufacturing Planning and Control,

f) Marketing,

g) Order Entry,

h) Payroll,

i) Personnel, and

j) Statistical Analysis.

Accounting, inventory control, order entry, payroll, and personnel applications primarily support operational control. Database management, financial management, manufacturing planning and control, marketing, and statistical analysis are frequently components of a manufacturing MIS and incorporate DSS concepts. Therefore, the last group of systems may be useful in management control and strategic planning. This suggests that by adopting a view of food service as a manufacturing function a MIS designer might find a rich source of commercially available software support. The validity of this assertion warrants further investigation.

E. AN INTEGRATED MANUFACTURING RESOURCE PLANNING MODEL

Cox and Adams [Ref. 17: pp. 75] developed a model of manufacturing resource planning that they submit represents an integrated DSS. Their model is presented in Figure 14. Cox and Adams [Ref. 17: pp. 73] state that manufacturing resource planning is a planning and control system based on

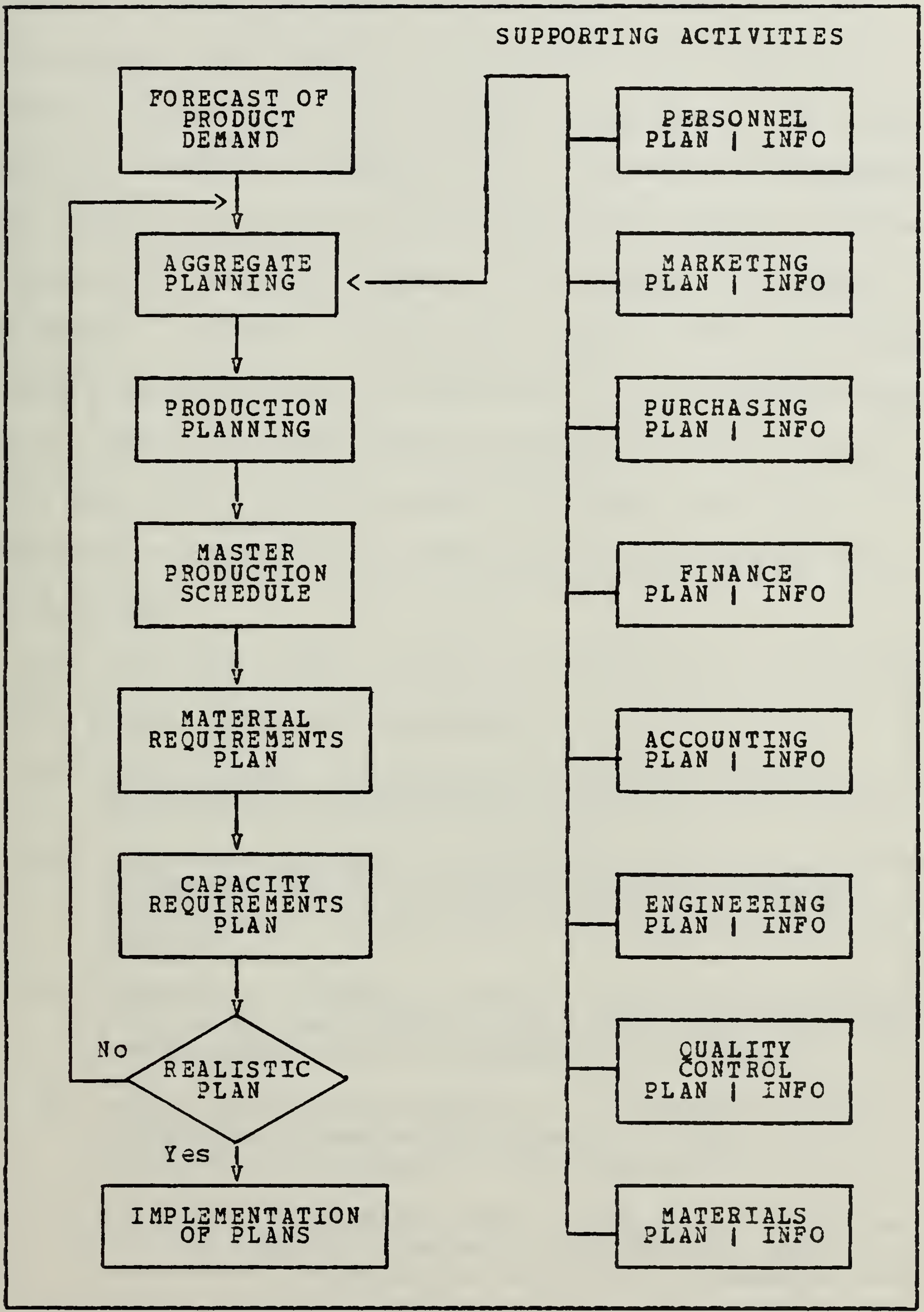

Figure 14: Model of Manufacturing Resource Planning

a dynamic simulation model of the total manufacturing environment. The objective of the model is to plan and control all resources of a manufacturing firm. The system provides information planning for all levels of management from control of production operations and support services to long-term management control and strategic planning. The model is dynamic in the sense that the effect of changes to input parameters may be simulated in the automated model, and the impact of these modifications on corporate objectives may readily be determined. The need for such a capability was previously identified for the design of a TRI-Food DSS.

Cox and Adams [Ref. 17: pp. 74-77] describe the function of the model's modules as follows:

a) Forecasting - an estimate of product demand that is furnished by the marketing staff;

b) Aggregate Planning - examination of alternative ways to manufacture the forecast of product demand resulting in a long-range production strategy by time period;

c) Production Planning - translation of the near-term portion of the aggregate plan into operating budgets and standards for all supporting functions;

d) Master Production Schedule - a breakdown of the production schedule into specific items to be manufactured in specific time periods;

e) Material Requirements Plan - time-phased requirements for raw materials needed to manufacture items identified in the master production schedule; and

f) Capacity Requirements Plan - determination of the physical plant capacity required to meet the master production schedule.

Each module of the model defines a discrete decision making activity. Therefore, DSS design activity must focus on the semi-structured and unstructured tasks of each activity level. Through the ability to simulate the effect of decisions in the total manufacturing environment, the model offers an integrated system of decision support.

The application of the model to food service operations is demonstrated by the following relationships:

a) Forecasting - projection of meal sales;

b) Aggregate Planning - long-range menu planning and budgeting;

c) Production Planning - near-term production planning of menus;

d) Master Production Schedule - master production menu;

e) Material Requirements Plan - time-phased provisions requirements as defined by the recipe file (bill of materials); and

f) Capacity Requirements Plan - production equipment utilization profile as defined by the recipe file.

From the preceding comparison it does appear valid to adopt a manufacturing point of view in food service software development. Since the requirements and design of manufacturing systems are well understood by the software industry, such an approach would reduce the risk in creating an automated food service system. Next a discussion of how the manufacturing planning resource model might be implemented shall be presented. The focus of this discourse shall be on mechanisms that support decision making.

F. METHODS OF DEMAND FORECASTING

The choice of forecasting system to be used in a manufacturing resource planning system is critical. In essence, the demand forecast sets the production process in motion by providing target levels of requirements. Therefore, an understanding of forecasting techniques is essential to the successful management of a manufacturing operation.

1. Survey of Forecasting Models

Wheelwright and Clarke [Ref. 18] surveyed the status of forecasting in numerous major corporations and found the following systems to be in common use:

a) Jury of Executive Opinion - a combination and averaging of top executives' views concerning the items to be forecast;

b) Time Series Analysis - identification of patterns representing a combination of trend, seasonal, and cyclic factors based on historical data which are then smoothed to eliminate the effect of random fluctuations and extrapolated into the future;

c) Regression Analysis - a statistical technique that fits a model of independent variables to historical data such that the model predicts the dependent variable of interest, i.e. a cause and effect relationship;

d) Sales Force Composite - a combination and averaging of salespersons' views concerning the items to be forecast;

e) Index Numbers - a method of comparing data to a base reference value, as a relative percent of that value, which may be combined and weighted to reduce fluctuations in data caused by seasonal or cyclic patterns;

f) Econometric Models - a system of simultaneous regression equations that take into account the interaction between various segments of the economy and/or areas of corporate activity;

g) Customer Expectations - a survey approach that statistically analyzes the expected needs and requirements of the firm's consumer market; and

h) Box-Jenkins Method - a highly sophisticated method of time series analysis that also provides statistics indicating the level of accuracy that may be expected for a given application.

2. Factors in Selecting an Automated Model

Of the generally used forecasting techniques only time series analysis, regression analysis, index numbers, econometric models, and the Box-Jenkins Method are adaptable to automation. Since index numbers require inference to be of predictive value, the use of this tool as a forecasting mechanism is questionable. Consequently, most automated forecasting methods rely on a form of regression analysis including econometric models, time series analysis including the Box-Jenkins Method, or a combination of these approaches.

To select an initial approach one should consider both of the following questions:

a) Do causal relationships exist whereby one or more independent variables may be used to predict a dependent variable, suggesting a form of regression analysis?

b) Is the dependent variable to be forecast dependent on time as illustrated in Figure 15, suggesting a form of time series analysis?

Intuitively, most food service managers would select time dependence as the more important consideration in

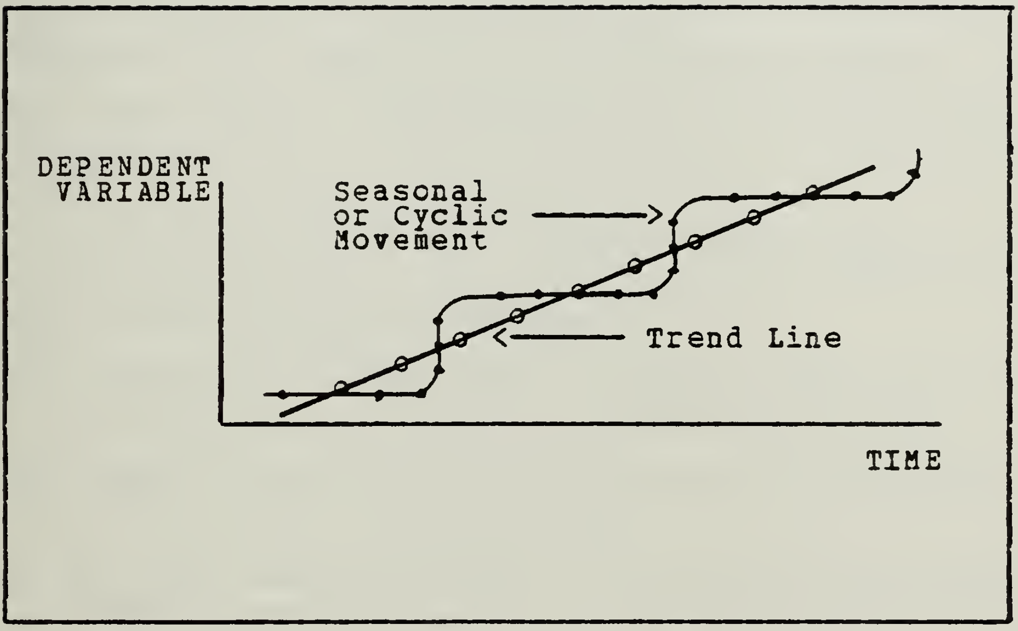

Figure 15: Illustration of Time Dependence

forecasting. The daily fluctuation of meal sales about a weekly trend and the monthly fluctuation about an annual trend are well known. These observations suggest the use of a time series model for menu demand forecasting.

3. <u>Selecting a Forecasting Model for TRI-Food</u>

Perhaps the most useful approach to time series analysis is the Box-Jenkins Method. The Box-Jenkins Method is not a specific type of time series analysis model but is an approach to the selection of a forecasting model. Box and Jenkins [Ref. 19: pp. 19] present their method as shown in Figure 16.

Box and Jenkins [Ref. 19: pp. 18-19] summarize their method of model building as follows:

a) Postulate a useful class of models from theory and practice;

b) Identify subclasses of these models by employing data and knowledge of the system;

c) Fit the tentative model to data and estimate the model's parameters;

d) Perform diagnostic checks to discover a possible lack of fit and determine the cause of an improper fit; and

e) Use the model if no lack of fit is discovered; otherwise, reiterate the process.

The preceding discussion is a highly simplified explanation of the Box-Jenkins Method. What is important, however, is the approach that Box and Jenkins present in their process. Fundamentally, the Box-Jenkins Method is a DSS. It takes the highly unstructured task of forecasting,

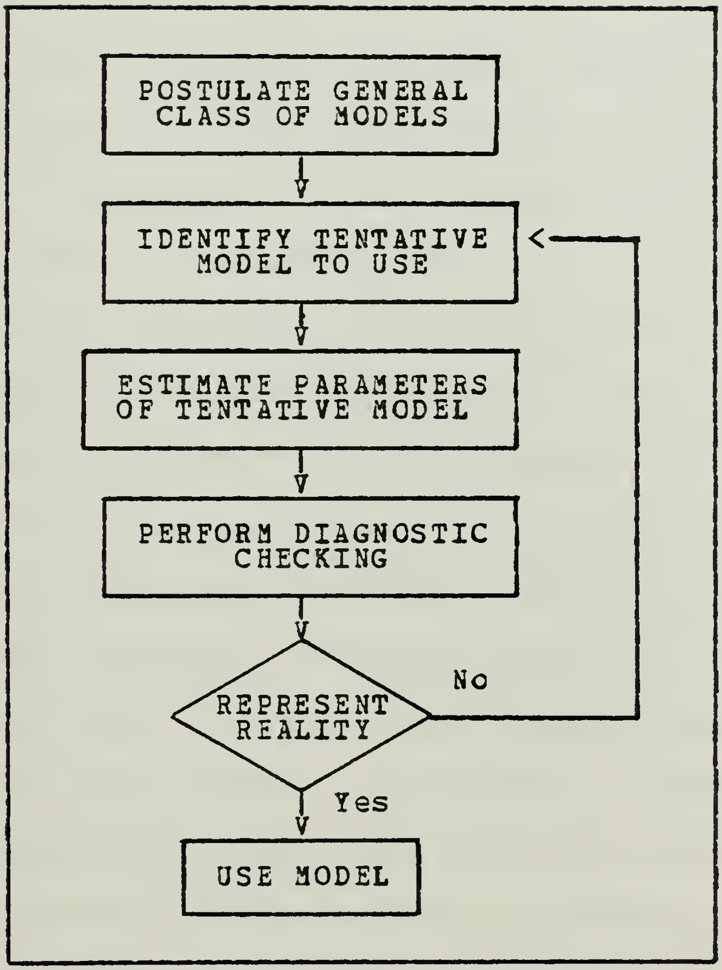

Figure 16: Model of Box-Jenkins Method

accepts a series of potential models, allows the system designer to test the applicability of all models and select a preferred model from a range of alternatives. For this reason, the Box-Jenkins Method would be an excellent method of demand forecasting to incorporate in the TRI-Food MIS.

G. MANUFACTURING PLANNING AND CONTROL SYSTEMS

The introduction of commercial computers in the mid-1950's offered business a new era of information processing capability. This new technology has had a profound impact on manufacturing industries in the area of logistics. Until the information processing power of the computer became available, solutions to the management and control of manufacturing finished products from raw materials had been incomplete and unsatisfactory. With the newfound ability to process and coordinate information improved planning and control systems have evolved. Chief among these new approaches has been material requirements planning (MRP).

MRP is a system of logic that converts a production plan for finished goods into time-phased requirements for materials that are necessary to manufacture the plan. At the center of this system is master production scheduling. The master production schedule defines target levels of production within discrete time periods. The schedule, when linked with MRP, provides a powerful, easy to use method for implementing the production plan. Therefore, an understanding

of the relationships among master production scheduling, material requirement planning, and their supporting mechanisms may provide insight into how military medical service might also improve its decision making processes.

1. Master Production Scheduling

Berry, Vollman, and Whybark [Ref. 20] present a model of manufacturing planning and control relationships as illustrated in Figure 17. The modules of the model in Figure 17 are similar to those previously discussed in the manufacturing resource planning model suggested by Cox and Adams. While Cox and Adams defined a hierarchial relationship of functions in their model, Berry, Vollman, and Whybark more clearly demonstrate the network flow of information that implements that planning model. They find that the controlling node of this network is the master production schedule.

Orlicky [Ref. 21: pp. 232-234] states that a master production schedule should not be confused with a forecast. A forecast represents an estimate of demand, whereas a master production schedule constitutes a plan of production. The master production schedule is a statement of requirements for end items by date and quantity. The period of time that the master production schedule spans is termed the planning horizon. The horizon may be divided into a firm portion and a tentative portion. The firm portion represents

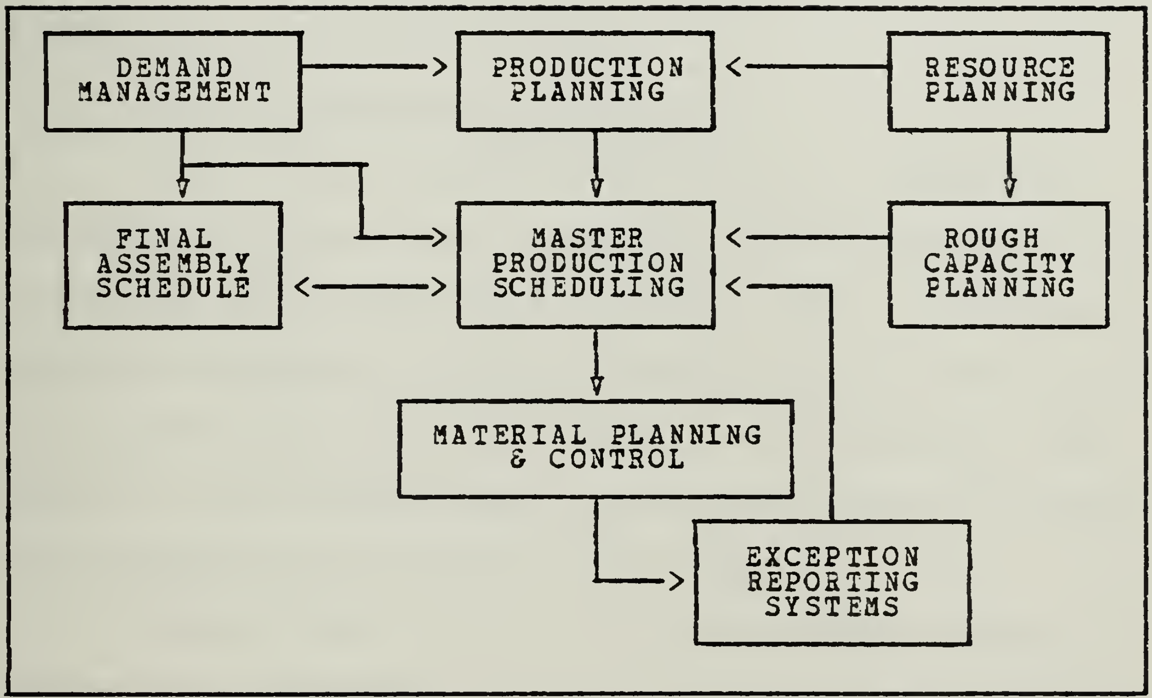

Figure 17: Manufacturing Planning and Control Relationships

the procurement and manufacturing lead time required to build specific quantities of end items.

The principles of master production scheduling are directly transferable to food service. The master production schedule is the manufacturing equivalent of the food service master menu. Since the methodology driving both systems is so similar, it should be of interest to the TRI-Food MIS designers how manufacturing firms implement the requirements of the master production schedule.

2. Material Requirements Planning

Material requirements planning is an information processing technique that is commonly used by manufacturing to meet the master production schedule. MRP is a method of logistics management designed to ensure that raw materials are available when and where needed. It incorporates the concept of time phasing into inventory management by adding a time dimension to inventory requirements.

Orlicky [Ref. 21: pp. 22] differentiates between dependent and independent inventory demand. Demand for a given inventory item is termed independent when such demand is not a function of demand for another item or product: independent demand must be estimated. Demand may be considered as dependent when it is derived from the demand for another item or product: dependent demand may be precisely calculated. Most requirements for manufacturing inventory are dependent on the end item quantities

identified in the master production schedule. This dependency of inventory on the master schedule then links inventory management to the master schedule. Since the master production schedule is time-phased, the replenishment of raw materials inventory may be accurately planned by time period.

It is the discrete time phasing capability of MRP that makes it such a powerful planning and control technique. The concept of time phasing is used not only for inventory replenishment but also for tracking the flow of materials through the production process. Knowing the manufacturing lead time to produce the components of an end item, the production planner may stage inventory at work stations and schedule both production employees and machine capacity through the master production schedule. By applying cost analysis to time-phased material and labor requirements, a MRP system may be extended to assist financial planners in forecasting production costs for budget planning. Control of the budget plan may be achieved by comparing actual production costs and quantities of materials used with standard product costs and material requirements. To implement this planning capability requires a supporting database for the MRP system--the product structure file.

3. <u>Product Structure Files</u>

In a manufacturing environment product structure imposes the primary constraint on the calculation of material requirements. Orlicky [Ref. 21: pp. 52-52] finds

that this computational difficulty arises from the number of levels of identifiable structure within the product. This structure is determined by the way that the product is manufactured. To visualize the effect of product structure one might consider the manufacture of an automobile. The completed automobile is assembled from numerous subassemblies, such as an engine, a chassis, and a transmission, which are themselves made from a multitude of components.

The engineering document that defines the product is the bill of materials. The bill of materials lists the components of each assembly and subassembly. The bill of materials for an end item assembly assumes a hierarchial, pyramidal structure of modules. Both the depth and complexity of this structure influence the difficulty in processing inventory data for material requirements planning.

Orlicky [Ref. 21: pp. 56] states that the downward progression from one product level to another is called an explosion. In executing the explosion the task is to identify the components of a given parent item and to ascertain the storage address of their inventory records so that these records may be retreived and processed. It is the bill of materials file that guides this explosion. Net requirements are then developed by allocating and reallocating on-hand inventory to the gross requirements in the level-by-level descent through the bill of materials file.

Additional factors tend to complicate material requirements planning. The ordering lead time of individual

inventory items must be taken into consideration. Subassemblies and components of an end item must be manufactured prior to the final assembly. This requires that the demand for these structural elements must be scheduled ahead of final assembly to ensure their availability by final assembly. Further, multiple requirements for an inventory item may exist within the same level of product structure. Obviously, the data processing activity that supports the material requirements planning function is a very complex task, especially in a firm which produces a wide variety of products.

These same factors present difficulty in food service inventory management. Recipes are the food service equivalent of the manufacturing bills of materials file. A recipe is normally viewed as a single level of inventory requirements. In most attempts to automate inventory management in food service the ingredient quantities of the recipe are multiplied by the recipe demand and aggregate requirements for all production recipes are summarized for a particular order cycle. This approach overlooks the true process by which recipes are produced institutionally. As in manufacturing a layering effect applies to recipe structure. This implies that the manufacture of some components of a recipe must precede others. As an example Figure 18 illustrates the layering of the structural components for an institutionally prepared apple pie.

To build an apple pie requires that some components must be produced before others. Bulk pie dough is often

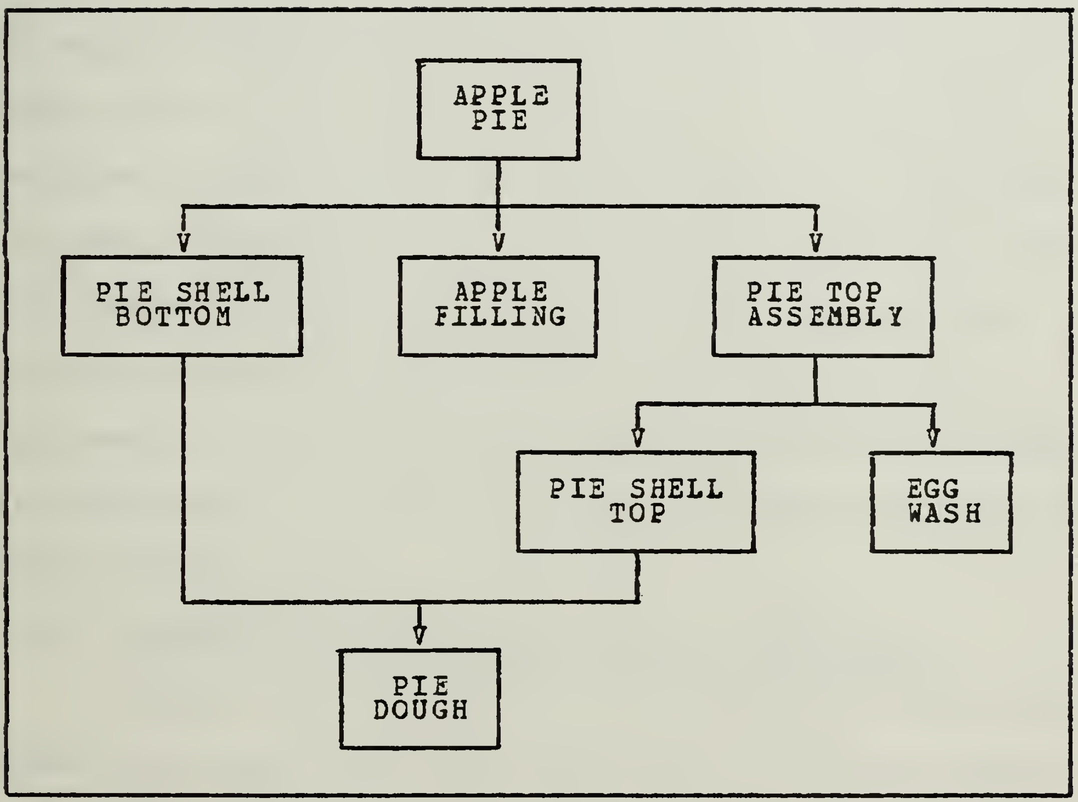

Figure 18: Modular Structure of a Recipe

produced on a weekly or bimonthly basis to increase the efficiency of bakery labor and to realize economies of scale in production. A top and a bottom crust must then be manufactured from the mass produced supply of dough. Both a pie shell top and egg wash must be available to prepare a pie top assembly. At the highest level all components are assembled and baked. To forecast the inventory demand for each modular component would prove to be a tedious task. Within a MRP system, that is supported by realistically structured product files, the task of inventory management is greatly simplified. After the end item demand is placed in the master production schedule, the MRP system then efficiently determines the correct time-phased material requirements. This concept of product structuring should be well understood by TRI-Food systems designers to ensure a usable software design.

4. Alternatives in Implementing an MRP System

Orlicky [Ref. 21: pp. 98-108] identifies two alternatives for a MRP system implementation--schedule regeneration and net change. In schedule regeneration every end item requirement in the master production schedule must be exploded. Every active bill of materials must be retrieved. The status of every active inventory item must be recomputed. Finally, voluminous output is generated. Schedule regeneration is a time consuming process that may only be performed

on a periodic basis because it requires significant data processing resources. As a result, changes in master production schedule, in product structure, and in planning factors must be accumulated until the next regeneration. Therefore, schedule regeneration is a batch data processing approach to MRP.

In the net change implementation the initial explosion may not be avoided, but the useful life of that explosion may be extended. After the initial explosion only localized, partial explosions are performed to reflect the effect of specific changes. Key concepts in this approach are that only part of the master production schedule is subject to an update explosion at any time, and the effect of transaction-triggered explosions is limited to lower level components of the end item that caused the explosion. Because the data processing requirements of the net change implementation are less voluminous than schedule regeneration, replanning may be performed more frequently. Therefore, net change supports an interactive, dynamic MRP environment.

5. Application of MRP to Food Service

As the preceding discussion demonstrates, there is a high degree of parallelism between the manufacturing and food service industries. Through the use of MRP, manufacturing firms have developed a software system that supports both operational and management control functions.

By adopting a net change implementation of MRP, an additional benefit may be derived from the system--support for stragetic planning. The net change capability of MRP facilitates simulation of the manufacturing environment. The effect of a decision may be tested within actual operating constraints. By reversing the change the MRP system is restored to its normal operating condition. This capability to support "what if" type questions provides manufacturing management with a valuable technique for testing the impact of strategic proposals.

In essence, MRP serves to model the production process. Alternative management decisions may be simulated in the model by modifying the system's input parameters. Then the outcome of those changes may be observed. This facility of MRP suggests that it may also be identified as a DSS. By incorporating the MRP concept in the TRI-Food MIS system, designers would provide military medical food service with an extremely powerful decision making resource that supports all levels of management planning and control.

Including a net change implementation of MRP would allow food service managers to address the following stategic issues that were previously identified as DSS design criteria:

a) Ensuring product differentiation by preserving the ability to provide full service menus and maintain service image through budgeting, standards, and variance analysis;

b) Ability to perform "what if" analysis to assist in developing programs responsive to the threat of OMB A-76 through planning and simulation of proposed systems; and

c) Methods for assessing the value of introducing new technologies through production process scheduling, capacity planning, and system simulation for analysis of trade-off between cost and performance of investigated systems.

H. MEASURING PRODUCTION PERFORMANCE

The need for support in monitoring performance was identified as a major strategic issue. One frequently used framework by which many firms accomplish this task is the process of budgeting. Budgets assist in planning and controlling business expenditures. Further, they aid in predicting operating results and financial conditions in the future. Planning involves the development of future objectives and the formulation of steps to achieve those objectives. Control is the means by which management assures that all parts of the organization function properly and attain the objectives of the business planning stage. Since a budgeting system supports both planning and control processes, mechanisms for budgeting should be included in a well-designed MIS.

1. Definition and Advantages of Budgeting

Garrison [Ref. 22: pp. 254] defines a budget as a detailed plan showing how resources will be acquired and used over some specific period of time. It represents a plan

for the future expressed in formal, quantitative terms. The master budget is a summary of all phases of a company's plans and goals, and how these objectives are to be achieved.

Garrison [Ref. 22: pp. 255] finds that one of the major values of budgeting is that is requires managers to bring planning to the forefront of their minds. Additionally, budgeting provides a vehicle for communicating these plans to an orderly way throughout an organization. Other advantages of budgeting include:

a) It forces managers to think ahead by requiring them to formalize their planning efforts;

b) It provides goals and objectives which serve as benchmarks for evaluating subsequent performance;

c) It frequently uncovers potential problems before they occur; and

d) It coordinates the activities of an organization by integrating the plans and objectives of its various parts.

2. Planning a Budget

Garrison [Ref. 22: pp. 261-272] offers a model of the budgeting process that is presented in Figure 19. The budgeting model suggests a complex network of information relationships. The sales forecast and resulting short-term and long-term sales budgets drive the process. The next step is to formalize production plans to develop budgets for production of sufficient finished goods to meet sales demand and adequate raw materials inventory to sustain production of finished goods. Then the plan is translated into budgets

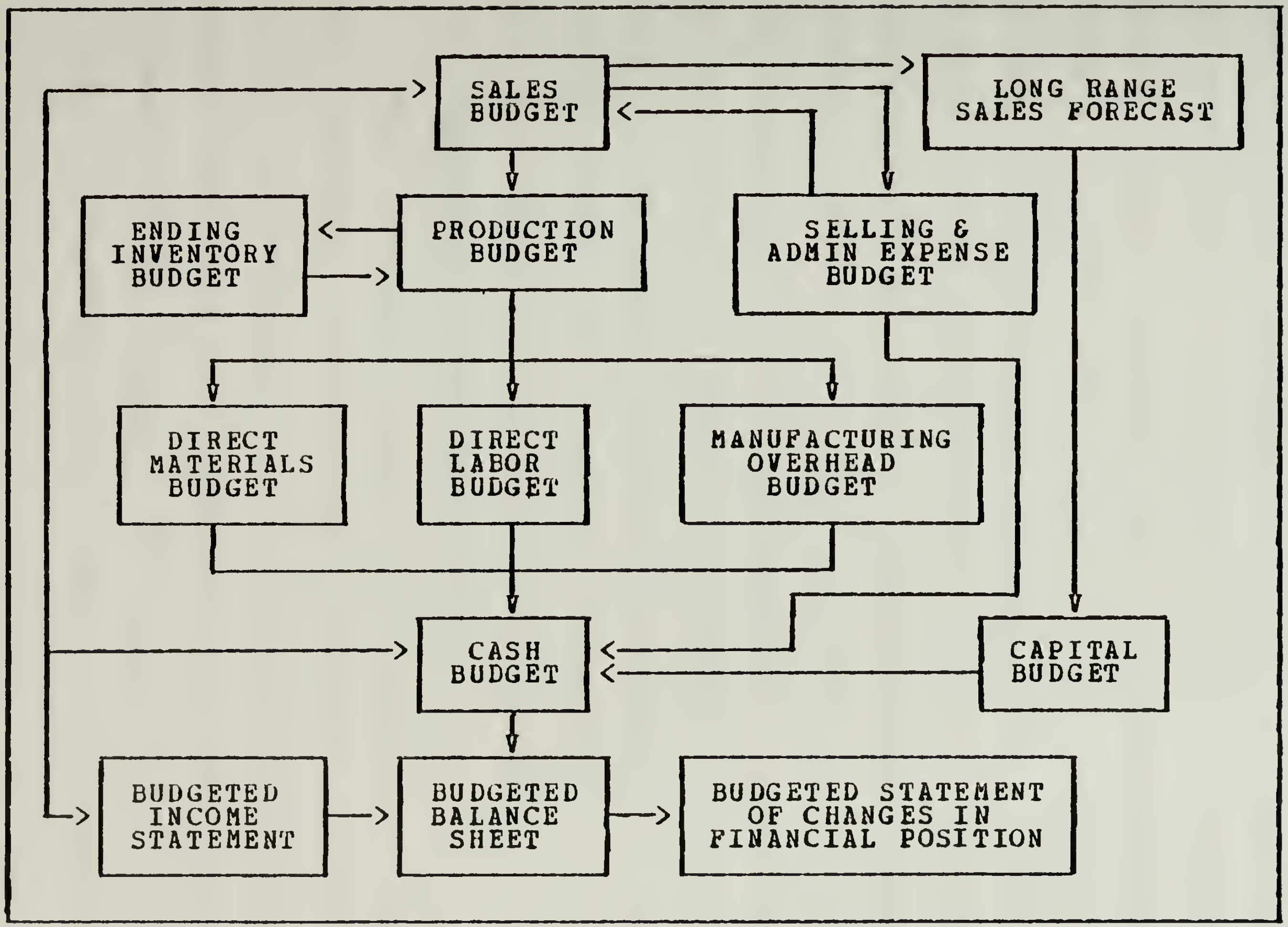

Figure 19: Model of Budgeting Relationships

for direct materials, direct labor, manufacturing overhead, and the indirect costs of selling and administrative expenses. The long-range sales budget is analyzed to determine the capital expense budget for long-range expansion and equipment replacement. The various budgets that have been defined so far are then summarized in a cash requirements budget that is used to determine if cash inflows will be sufficient to cover cash outflows. If cash inflows are inadequate, the firm must arrange for either short-term or long-term financing to cover cash requirements deficits. As a final step in the budgeting process, the firm prepares a budgeted income statement, a budgeted balance sheet, and a budgeted statement of changes in financial position. If the performance of the operating plan is deemed unacceptable, the budgeting process is reiterated to explore alternative approaches to satisfy the anticipated demand for goods and services. Budgeting, therefore, tends to be a process of simulation for profit maximization.

3. Budgeting and the TRI-Food MIS

While it is not suggested that agencies of the Federal Government should operate as profit making entities, they do have a responsibility for ensuring that the cost of providing their service is minimized consistent with the achievement of their mission. This point is reinforced by the intent of the OMB A-76. If support services identified in

the Circular, including military medical food service, cannot be operated economically, it is then in the public interest to seek alternate means by which to provide those services. Ensuring that operating costs are held to an acceptable level is a management responsibility. The planning and control functions of budgeting serve to assist managers in both executing and meeting that responsibility. Therefore, budgeting concepts and mechanisms for monitoring compliance with budgets should be included in the TRI-Food MIS. This need identifies a requirement for DSS's that support budget planning and programming. Financial planning and analysis models are commercially available as indicated in Snyder's [Ref. 16] summary of software systems and Clift's [Ref. 23] review of financial modeling systems.

Garrison [Ref. 22: pp. 306] states that in controlling resources managers have two types of decisions to make--decisions relative to prices paid and decisions relative to quantities used. Managers are expected to pay the lowest possible prices that are consistent with the firm's desired level of product quality. Concurrently, they are expected to consume the minimum quantity of whatever resources they have at their command. The answer to this control problem lies in standard costs. A standard may be defined as a benchmark for measuring performance. These standards serve as the basis for developing budgets.

In budget control systems cost and quantity standards are set for all three elements of production--materials, labor, and overhead. Quantity standards, as scheduled in manufacturing bills of materials, bills of labor, and manufacturing overhead accounts, identify what should be used in producing a product or service. Cost standards for these input variables define what the unit cost of a product or service should be. By measuring actual quantities and costs of inputs against these standards management may determine if the firm is operating within the budget plan.

The budget serves as a normative model of what should be. Cost accounting is a descriptive analysis of what is. The integration of these two concepts allows management to identify differences between the two processes. Through variance analysis managers may focus on the cause of differences and take corrective action to resolve or reduce those differences. Therefore, the budget is a mechanism for problem finding, and variance analysis is a method of problem solving. Both mechanisms are linked through the use of standards.

Including budgeting in the TRI-Food MIS would allow food service managers to address the following strategic issues that were previously identified as DSS design criteria:

a) Monitoring of Medical Department performance in relation to commercial contractors through budgeting, standards, and variance analysis;

b) Ensuring product differentiation by preserving the ability to provide full service menus and maintain service image through budgeting, standards, and variance analysis;

c) Compliance with OMB A-76 and use of the resultant managerial accounting information to develop forecasts, budgets, and standards; and

d) Incremental budget planning and programming systems to ensure adequate funding to meet consumer demand for service through trend analysis, long-range forecasting, budget planning, and budget programming for inclusion in the Program Objective Memoranda of the Service.

I. MEASURING NUTRITIONAL PERFORMANCE

In a sense, the practice of nutrition serves a dual role when applied to medical food service. In the clinical environment it is an important aspect in the treatment and care of hospitalized patients who are recovering from specific disease states. In the administrative domain the consumption of nutritionally adequate meal service should serve as a measure of both quality control and compliance with performance standards. Therefore, standards and processes to monitor the achievement of those standards should be considered in the design of a medical food service MIS.

The TRI-Food SFR does address the above issues and defines requirements for nutritional analysis capabilities for both patient and general menu planning. What it does not provide, however, is a means by which to monitor compliance with nutritional performance standards for Medical Department review. A method of monitoring nutritional status should

be included in the TRI-Food SFR so that both MTF food service officers and agency food service program managers may readily be aware of performance in this essential area of the military medical food service program.

This requirement suggests an ongoing statistical analysis of the ability of individual MTF's to meet specific Recommended Daily Allowances (RDA's) for the healthy consumer population and adjusted allowances for those patients receiving therapeutic nutritional care. Exceptions to standards then might be investigated and support provided to MTF's in achieving desired standards of nutritional performance. Also, this ongoing analysis would serve to implement important, but computationally time consuming, aspects of the patient care audit requirements of the Joint Commission on Accreditation of Hospitals (JCAH).

J. SYNTHESIS OF TRI-FOOD DSS DESIGN CRITERIA

The preceding discussion has covered a variety of topics concerning the development of a medical food service MIS that incorporates DSS concepts. It was noted that the design of a complex software system is inherently a high rish undertaking. In the case of the TRI-Food MIS program, risk is amplified by the lack of experience which most potential users have had with automated systems. It was suggested that to minimize risk the use of existing software designs should be considered. In this manner users could investigate a

range of software solutions that have been proven in other operations before committing to a specific design. It was offered that such an approach would improve the probability of a successful implementation.

Existing food service software systems were reviewed. While several vendors supply packages that support operational control and some aspects of management control, no one system was found that offered a complete food service system with both MIS and DSS potential. After extending the search for software solutions it was discovered that a high degree of parallelism exists between food service operations and manufacturing industries. By adopting a manufacturing point of view it was demonstrated that a rich source of software systems, possessing both MIS and DSS potential, could then be considered.

A manufacturing resource planning model was presented that describes an integrated system of support for managerial decision making tasks. These tasks identify discrete managerial responsibilities in a manufacturing environment that range from operational control through strategic planning. It was suggested that the Box-Jenkins Method would be a useful means by which to provide a forecasting DSS in a food service environment. Next master production scheduling and material requirements planning concepts were examined. These software applications are frequently used by manufacturing industries to implement the production planning,

master production scheduling, material requirements planning, and capacity requirements planning modules of the resource planning model. It was then demonstrated how these concepts could be directly applied to a food service operation. Finally, it was shown how, by adopting a net change implementation of MRP, the system could support aggregate planning through simulation of planning alternatives.

Since business firms commonly use budgeting to facilitate planning and control, the budgeting process was reviewed, and its advantages were discussed. By developing standards business plans may be translated into budgets. Through variance analysis managers may exercise control in their area of responsibility to meet planned objectives. Financial planning and analysis models are widely available in the commercial software market. It was further suggested that these monitoring activities, when employed in medical food service, should include the important aspect of nutritional performance.

As a result of this exploration of TRI-Food DSS design alternatives, a need for a variety of DSS planning and programming modules was identified. These requirements include:

a) Menu Planning,

b) Demand Forecasting,

c) Production Planning,

d) Capacity and Resource Planning,

e) Material Requirements Planning,

f) Performance Standards Planning, and

g) Budget Planning and Programming.

Standards assist in recognizing problems with performance. Deviation from standards may be investigated through variance analysis. Requirements for variance analysis in a TRI-Food MIS include:

a) Variance of nutritional performance as a measure of quality control;

b) Variance of production performance from material, labor, manufacturing overhead, and other budget standards; and

c) Variance between actual and planned meal sales to detect change factors in the sales forecasting system.

A model of these decision making and analysis requirements is presented in Figure 20. The model suggests a complex network of functions. Planning and programming modules identify models needed to facilitate semi-structured food service decision making tasks. Analysis modules offer a method of adding structure to both semi-structured and highly filtered exception reports. To facilitate the analysis of exception reports it is suggested that exceptions be grouped into variances of a general nature, i.e. nutrition, forecasts, and production, and prioritized by magnitude of the variance. In this manner a manager may deal with a series of similar, potentially related problems during a variance analysis session. By comparing problems of a general nature

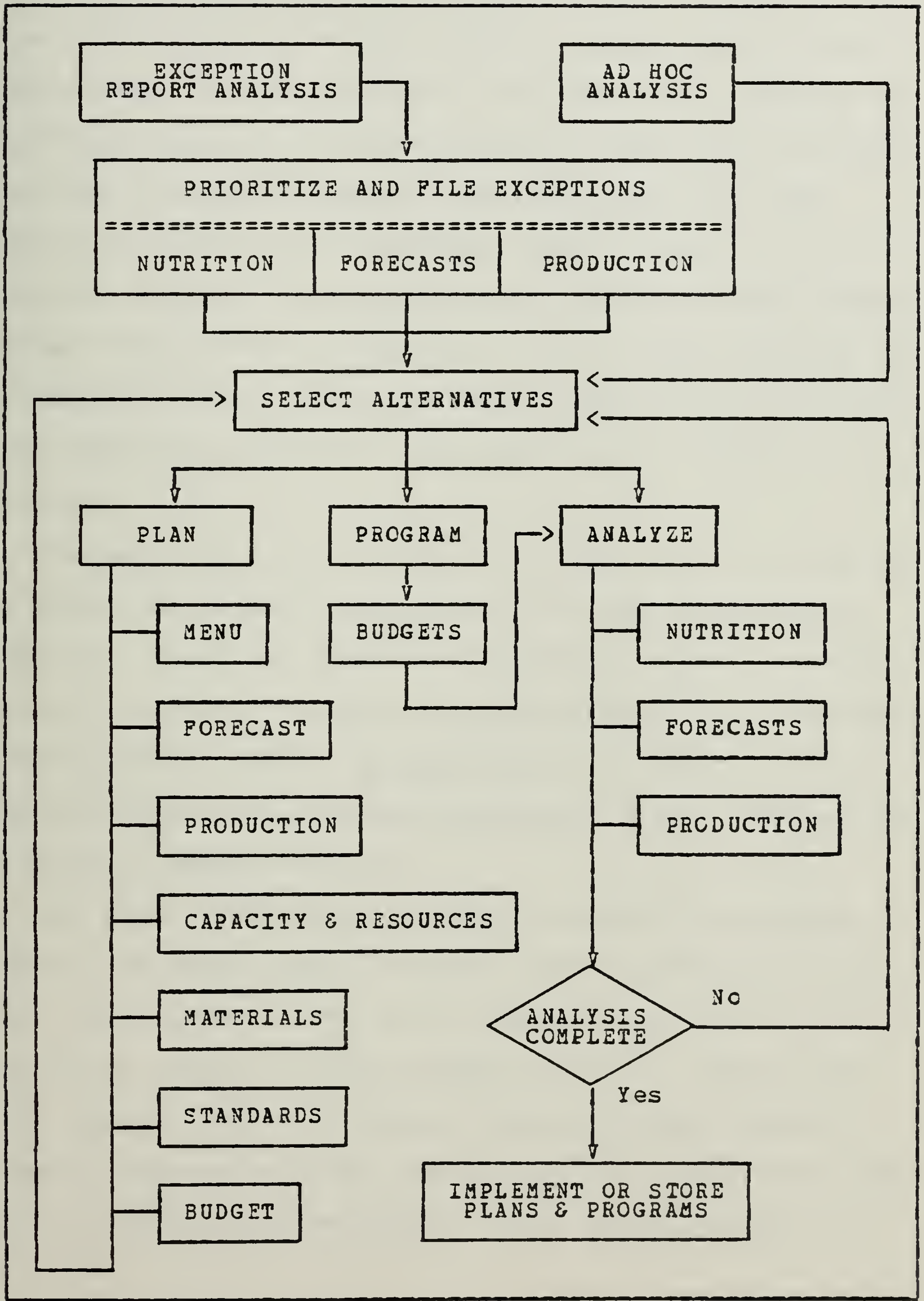

Figure 20: Model of TRI-Food DSS Requirements

with current standards and past performance, a manager could then begin to break down the general problem into a group of subproblems. If some of these subproblems were amenable to modeling, then he or she could select a model from the planning and programming modules with which he or she could explore solutions to the problem. After a range of solutions was created, the manager could then select and implement the most appropriate alternative. In all cases solutions must be compared to performance standards before exiting the model. This comparison identifies the degree of risk inherent in the solution.

The model in Figure 20 may be entered either by choosing to analyze performance exceptions or by specifying *ad hoc* analysis. Entry for analysis of exception reports primarily serves to support the semi-structured problems of operational and management control. *Ad hoc* analysis is viewed as more appropriate for unstructured management control problems and strategic planning functions.

The model, when combined with a database system that offers rich query capabilities and report generation facilities, will support a variety of cognitive styles. It structures problem finding through exception reporting but also supports intuitive thinkers through *ad hoc* analysis. It suggests numerous modeling and data analysis techniques that may be selected and combined to assist in the process of

information evaluation. For these reasons the model of DSS requirements offers effective support for many styles of decision making.

In the next chapter the DSS modules proposed in Figure 20 shall be combined with the TRI-Food SFR modules and evaluated in the Gorry and Scott Morton MIS framework. Then recommendations shall be made as to how the suggested system of decision support might be designed. Finally, an analysis of the benefits of adopting the recommendations shall be presented.

VII. CONCLUSIONS AND RECOMMENDATIONS

The exploration of TRI-Food DSS design alternatives identified software systems that will provide decision support for military medical food service. During the analysis an integrated model of DSS requirements was proposed that incorporates these software applications.

This final chapter shall illustrate how the suggested network of decision support will enhance the TRI-Food MIS. Then recommendations shall be made that will assist TRI-Food analysts and designers in implementing food service DSS requirements. Finally, the benefits of adopting these recommendations shall be discussed.

A. CONCLUSIONS

Adding the proposed model of decision support to the TRI-Food MIS would substantially improve the system. An analysis of the enhanced MIS within the Gorry and Scott Morton MIS framework would appear as presented in Figure 21. In Figure 21 additions are indicated by uppercase module names. As one may readily see, including these modules provides a much richer MIS. The improved system offers a broad spectrum of resources for each level of managerial decision making. Further, all levels of managerial activity are well supported by both structured decision systems and decision support systems.

	OPERATIONAL CONTROL	MANAGEMENT CONTROL	STRATEGIC PLANNING
STRUCTURED TASKS (SDS) ==>	Inpatient Outpatient Inventory Service Personnel	Nutritional Analysis Financial Management Short-Term Forecasts Training Quality Control	STANDARDS PLANNING LONG-TERM FORECASTS
SEMI-STRUCTURED (DSS) ==> UNSTRUCTURED TASKS	Production Scheduling MATERIAL MANAGEMENT STANDARDS MONITORING & CONTROL	Menu Planning MASTER PRODUCTION SCHEDULING CAPACITY PLANNING BUDGET PREPARATION FACILITY VARIANCE ANALYSIS	RESOURCE PLANNING PROGRAMMING BUDGETS FINANCIAL ANALYSIS NEW PRODUCT PLANNING Research PROGRAM VARIANCE ANALYSIS

Figure 21: Analysis of an Enhanced TRI-Food MIS

During the analysis of DSS design alternatives it was discovered that software applications do exist which would effectively support TRI-Food DSS requirements. An integrated system of decision support for all levels of management was developed from a manufacturing resource planning model. Then it was demonstrated how the model could be implemented with material requirements planning and master production scheduling. Next it was shown that by extending the time phasing capabilities of MRP the model could further support financial planning and performance analysis through budgeting and development of cost and quantity standards. This extended version of MRP is generally known as MRP II. MRP II software is now available in the commercial data processing market.

By combining MRP II software with a database system that has both rich query capabilities and report generation facilities TRI-Food MIS designers would provide food service managers with a very powerful planning and control system. Supplementing the basic manufacturing planning and control system with DSS's that support specific planning tasks would further increase the capabilities of the TRI-Food MIS. An integrated network of such decision making tasks has been identified in this analysis. Enhancements might include software to support the Box-Jenkins Method for demand forecasting, Balintfy's CAMP program for optimal menu cost

planning, and financial analysis models for aggregate planning and budgeting.

B. RECOMMENDATIONS

It is recommended that the TRIMIS Program Office conduct a feasibility study of using MRP II software to implement an enhanced TRI-Food MIS. An Appendix is provided to assist in conducting such a study. The Appendix is a partial list of independent software vendors and hardware vendors who market MRP II applications software. During this study systems should be assessed for their ability to incorporate new applications. This suggests that MRP II software should be both modular and designed to interface with and integrate input from additional decision making models. Further, the MRP II vendor should support his or her software with a database system that includes a robust query language and flexible report generation facilities.

One design implementation might appear as presented in Figure 22. A MRP II software system would be used to support ongoing production requirements. The output of the production system would be compared with planned material and cost standards. Variances from those standards would create an exception report for the food service manager's action file. In all cases production performance and costs would be captured by the database system. Cost accounting information would then be generated to support both

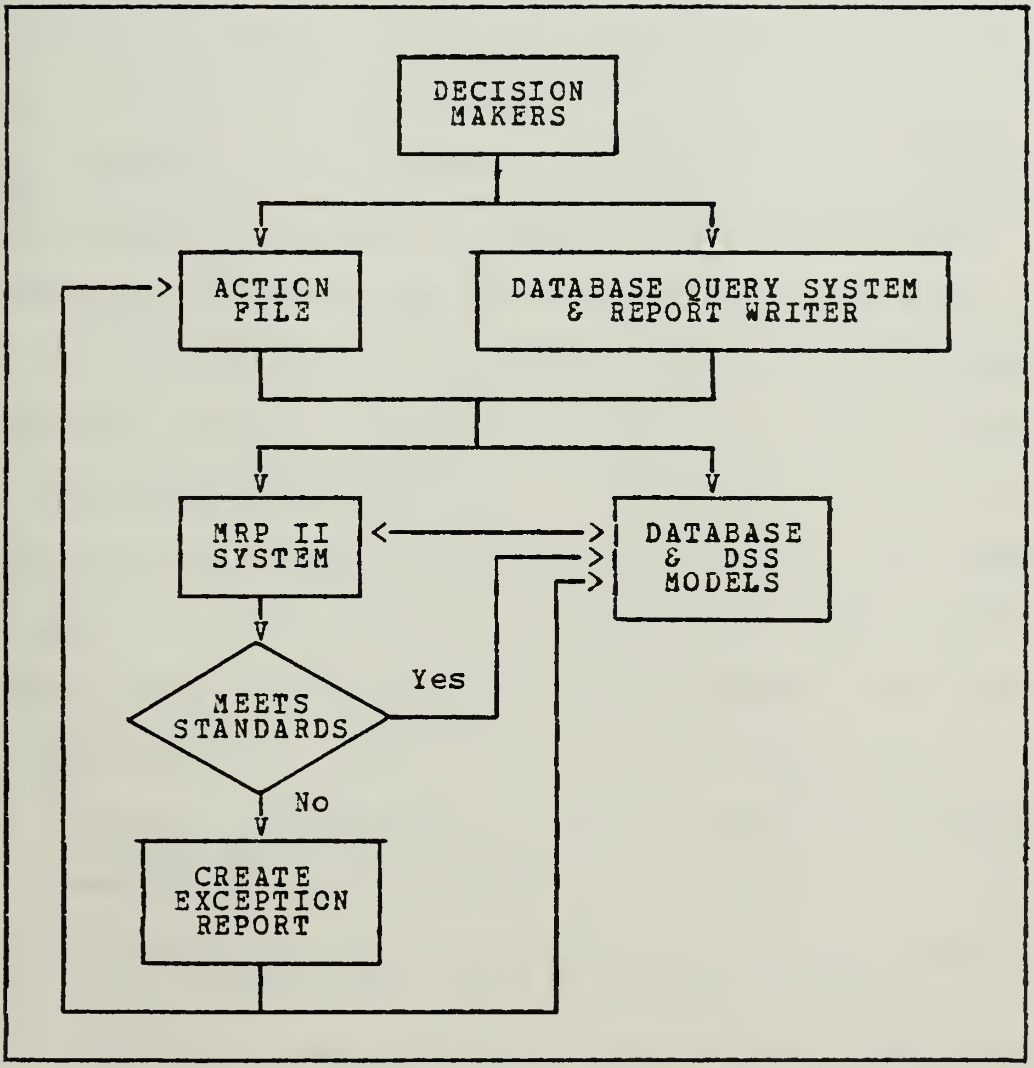

Figure 22: Implementation of a TRI-Food MIS

managerial decision making and the reporting requirements of Medical Departments and OMB A-76. In problem analysis the decision maker could enter the data processing system through either the action file or the _ad hoc_ query facilities of the database system. In either case he or she would have access to both the specialized DSS model bank of the database system to create problem solutions and the net change capabilities of the MRP II system to simulate the effect of those solutions. Such a system could be made affordable by providing smaller MTF's with transaction processing microcomputers or minicomputers and data communications facilities that link to a larger host MTF system for major applications processing.

For military medical food service to operate in a MRP II environment it must possess a database that supports MRP processing logic. Therefore, it is recommended that the following actions by taken by the TRI-Food Committee:

a) Create a comprehensive file of regular and therapeutic recipes as bills of materials that accurately reflect manufacturing structure;

b) Incorporate labor and production equipment capacity requirements into product structure files;

c) Develop a data dictionary and database schema and subschema for both administrative and clinical data requirements; and

d) Investigate and select for the TRI-Food MIS specific DSS's that would most optimally support the functional requirements of the manufacturing resource planning model in a medical food service environment.

C. BENEFITS OF THE PROPOSED APPROACH

Benefits that will be derived by adopting these recommendations include:

a) The proposal defines a pervading system of logic that substantially meets the requirements for the current TRI-Food SFR and suggested DSS enhancements;

b) The approach will reduce both risk and development lead time in implementing the TRI-Food MIS as compared to a custom design effort;

c) By using commercial software packages the system may be easily proliferated since the basic software will have already been tested and debugged elsewhere;

d) With reduced software errors upon initial installation users may devote less time to testing the reliability of software and more time to implementing the system; and

e) Commercial software is generally both well documented and modular which supports more rapid evolution of an initial system.

APPENDIX

MATERIAL REQUIREMENT PLANNING SOFTWARE VENDORS

American Software
443 East Paces Ferry Road
Atlanta, GA 30305
(404) 261-4381

Arthur Andersen and Company
69 West Washington Street
Chicago, IL 60602
(312) 346-6262

Arista Manufacturing Systems
7830 Silas Creek Parkway
Winston-Salem, NC 27107
(919) 722-5167

Cincom Systems Incorporated
2300 Montana Avenue
Cincinnati, OH 45211
(513) 662-2300

Interactive Information Systems
10 Knollcrest Drive
Cincinnati, OH 45222
(513) 761-0132

Martin Marietta Data Systems
Suite 300
6301 Ivy Lane
Greenbelt, MD 20770
(301) 345-0100

Mitrol Incorporated
1 New England Executive Park
Burlington, MA 01803
(617) 273-4111

Software International
2 Elm Square
Andover, MA 01810
(617) 475-5040

Burroughs Corporation
Burroughs Place
Detroit, MI 48232
(313) 972-7000

Digital Equipment Corporation
200 Forest Street
Marlboro, MA 01752
(617) 467-6885

Hewlett-Packard
3003 Scott Boulevard
Santa Clara, CA 95050
(408) 988-7000

Honeywell Information Systems
200 Smith Street
Waltham, MA 02154
(617) 895-6000

IBM Data Processing Division
1133 Westchester Avenue
White Plains, NY 10604
(914) 696-1900

Sperry Univac
P. O. Box 500
Blue Bell, PA 19422
(215) 542-4011

Xerox Computer Services
5310 Beethoven Street
Los Angeles, CA 90066
(213) 306-4000

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